IN TWO SECTIONS—SECTION ONE

MECHANICAL ENGINEERING

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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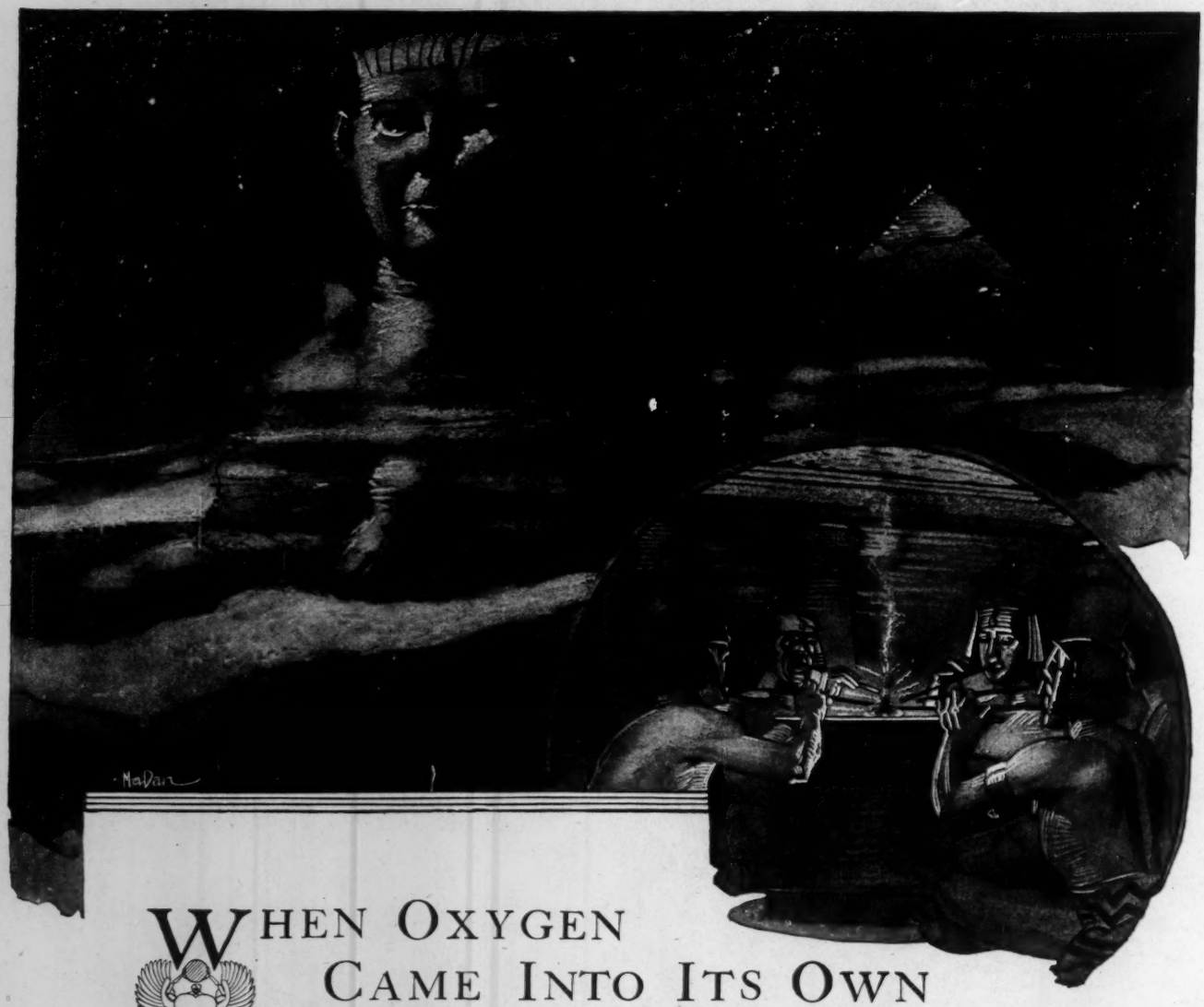
IN THIS NUMBER

METAL CASTINGS:
Six Papers on the State of the Art from the Standpoint of the Engineer and Designer

RECENT POWER PLANT DEVELOPMENTS:
A Review of Four Current Articles of Great Importance Given in the Engineering Survey Department

AUGUST 1920

PUBLISHED MONTHLY BY THE SOCIETY
29 WEST 39TH STREET, NEW YORK, U.S.A.



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Mechanical Engineering

The Journal of The American Society of Mechanical Engineers

VOLUME 42 AUGUST, 1920 NUMBER 8

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C. 55. The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions.

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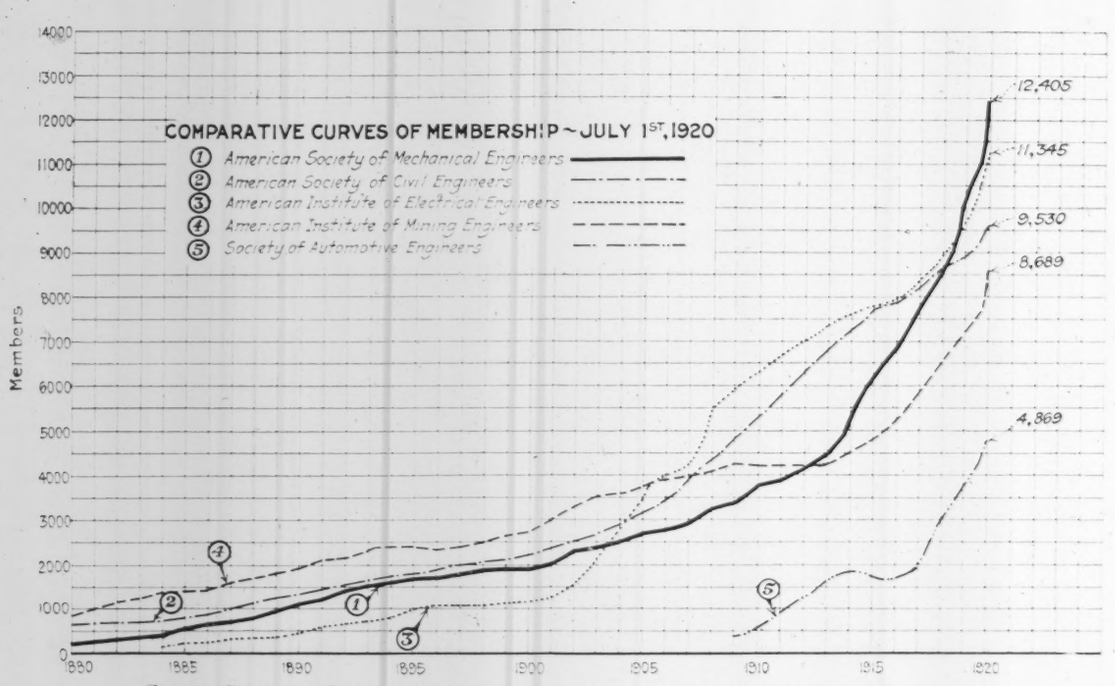
The Value of Membership in Engineering Organizations

ENGINEERS are coming more and more to appreciate the value of association with their fellow-engineers. The individual engineer, however, can only take his proper place in the community and receive the recognition that is due him through such organizations as the local societies and clubs and the great national organizations which are devoted to the advancement of the various branches of engineering. In union there is strength.

The greatest step, however, toward the attainment of that professional unity so long desired has just been taken. A general organization, nation-wide in its scope and representing the entire engineering profession in the same way that the American Bar Association and the American Medical Society represent the legal and medical professions, and the United States Chamber of Commerce the business men, has just been founded by delegates of 71 technical organiza-



CURVES SHOWING GROWTH OF MEMBERSHIP IN THE NATIONAL ENGINEERING SOCIETIES

These Curves Show How Engineers Are Grasping the Opportunities for Participation in the National Engineering Movements

tions who met in Washington on June 3 and 4. The object of the new organization could not be higher: *Service to others and the furthering of the interest of the public through the use of technical knowledge and engineering experience.*

Resolutions were also adopted endorsing:

(*a*) An increase in the salaries of teachers in engineering colleges

(*b*) The prompt enactment by Congress of legislation necessary to give effect to the principles of the report submitted by the Reclassification Committee

(*c*) The bill for the creation of a Department of Public Works to embrace the constructional and engineering activities of the National Government.

The formation of this organization, which will be known as The Federated American Engineering Societies, has been characterized by the engineering press as "the biggest item of news of its kind in the engineering history of the country." Membership in the new organization is limited to national, local, state, regional, and allied technical organizations and affiliations. *There are to be no individual memberships.* Each organization will be entitled to one voting delegate for each thousand members. This provision but emphasizes for the individual engineer the growing importance of belonging not only to his local engineering organization, but to the National Society covering his specialty as well.

Your mechanical engineering associate—not a member of the A. S. M. E.—will welcome a suggestion from you that he participate in the work of the Society.

Applications received by August 16 should be acted upon by November, and those elected, upon the payment of initiation fee and dues to October 1921, totaling for voting members only $37.50 ($23.34 for Juniors) payable December 1, will be entitled to:

(*a*) Attend the Annual Meeting, December 7-10, 1920, admission to which may be restricted to members

(*b*) MECHANICAL ENGINEERING, The Journal of The American Society of Mechanical Engineers

(*c*) A copy of the 1921 Year Book and listing therein

(*d*) A copy of the 1920 Transactions

(*e*) A copy of Condensed Catalogues of Mechanical Equipment.

In addition to the Annual and Spring Meetings (the latter at Chicago, Ill., in 1921), meetings will be held regularly beginning next October in 42 centers throughout the United States. These centers and the secretaries of the committees at these places at present are as follows:

Akron, Ohio, E. P. Roberts, Room 21, 80 South Main St.
Atlanta, Ga., R. S. King, Georgia School of Technology.
Baltimore, Md., A. G. Christie, Johns Hopkins University.
Birmingham, Ala., J. A. Sirnit, Brown-Marx Building.
Boston, Mass., D. K. Dean, 88 Broad St.
Bridgeport, Conn., James Coulter, Automatic Machine Company.
Buffalo, N. Y., W. W. Boyd, 1888 Elmwood Ave.
Chicago, Ill., J. D. Cunningham, 565 Washington Boulevard.
Cincinnati, Ohio, J. T. Faig, Ohio Mechanics Institute.
Cleveland, Ohio, C. H. Day, 14th Floor, Hotel Statler.
Colorado, Wm. Lester, Vulcan Iron Works, Denver.
Columbus, Ohio, Wm. T. Magruder, Ohio State University.
Detroit, Mich., M. W. Taber, 1858 Penobscot Building.
Eastern New York, J. L. Hughes, Watervliet Arsenal, Watervliet, N. Y.
Erie, Pa., J. St. Lawrence, G. E. Co.,
Hartford, Conn., W. C. Beckley, Whitlock Coil Pipe Co.
Houston, Texas, H. W. Fletcher, Hughes Tool Company
Indianapolis, Ind., Chas. Brossman, 1503 Merchants Bank Building.
Los Angeles, Cal., R. W. Lacy, 600 Washington Building.
Meriden, Conn., F. L. Rowntree, Foster, Merriam Co.
Metropolitan, S. N. Castle, 29 West 39th Street, New York City.
Mid-Continent, D. E. Foster, 303 South Cincinnati Ave., Tulsa, Okla.
Milwaukee, Wis., Fred H. Dorner, 642 Wells Building.
Minnesota, Albert Buenger, 716 Capitol Bank Building, St. Paul.
New Haven, Conn., E. H. Lockwood, Yale University.
New Orleans, La., Walter B. Moses, 636 South Peters St.
Ontario, C. B. Hamilton, The Hamilton Gear and Machine Co., Toronto, Canada.
Oregon, E. W. Lazell, 537 Railway Exchange Building, Portland.
Philadephia, Pa., Chas. Penrose, 611 Chestnut St.
Pittsburgh, Pa., Kenneth F. Treschow, 586 Union Arcade Building.
Providence, R. I., J. D. Guillemette, 740 Grosvenor Building.
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Toledo, Ohio, John B. Nordholt, The Toledo Steel Castings Company.
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Virginia, A. H. Warx, Alco Plant, American Alco Co., Richmond.
Washington, D. C., A. R. Cheyney, Electrical Experimental Aide, Bureau of Steam Engrg., U. S. N.
Washington State, E. O. Eastwood, University of Washington, Seattle.
Waterbury, Conn., J. R. Putnam, Waterbury Clock Co.
Worcester, Mass., Chester T. Reed, Reed & Prince Manufacturing Co.

Preliminary Request for Membership

(Date) .....

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29 West 39th Street, New York.

Desiring admission to The American Society of Mechanical Engineers, I submit the following:

Born at ..... (City) ..... (State) ..... (Date)

Education ..... (Name of School)

College Degree ..... (College) ..... (Year)

Present Position ..... (Title)

..... (Name of Concern)

I hereby agree that I will subsequently sign the prescribed application for membership issued by the Society, and comply with all the conditions and provisions thereof.

..... (Signature of Applicant)

Mailing Address .....

To Every Member of the A. S. M. E.

Solemn Warning!!!!

THE 1919 Annual Meeting taxed the capacity of the Engineering Societies Building and the crowd will be still larger for the 1920 meeting. Six of the new Professional Sections will hold sessions covering the vital questions in their field. These well-planned programs with the ever-popular social and entertainment features guarantee an attendance that is causing the Committee on Meetings and Program some concern. Serious consideration must be given to a limitation of guest privileges or the renting of larger halls for some of the sessions.

This warning is double: First—If you have non-member engineering friends who would benefit from attendance at the Annual Meeting and whom you are planning to bring, it would be better to play safe and file their applications for membership *now*. Second—Put a note in your tickler for October, to check up the Annual Meeting program, which will be announced at that time, and determine whether you will be on hand December 7-10 at the Meeting. Then make your hotel reservations, because New York hotels are always crowded in December.

The Professional Sections on Fuel, Industrial Engineering, Machine Shop, Power, Railroads and Textiles are the ones planning Annual Meeting sessions. If you have a paper in process or under consideration on any of these subjects, advise the Secretary of the Society at once, so that your paper may have consideration in the arrangement of the program.

Contributors and Contributions in This Number

Metal Castings—A Group of Papers on the Usefulness and Limitations of Various Types of Castings

At the Spring Meeting of the A.S.M.E. the Society's Sub-Committee on Foundry Practice presented a symposium on castings which outlined in brief form the latest available information as to the present state of the art of foundry practice. An abstract of the papers of this symposium appears as the leading article of the present issue. It treats under separate heads malleable castings, die castings, aluminum castings, steel castings, gray-iron castings, and brass and bronze castings, and in general each paper discusses the special properties of a particular kind of casting and where it is to be preferred to other forms of cast metal. The authors of the various papers are acknowledged authorities and their contributions can be accepted in the light of a thoroughly reliable report.

Pipe Lines for Transporting Natural Gas, By Clifford E. Brock, Bartlesville, Okla.

With the development of the natural-gas industry there has been a corresponding change in the method of its transportation. The first line, laid in Pennsylvania in 1872, was constructed of wood. Later, as metal lines came into common use, the chief difficulty encountered was that of properly joining one pipe with another. Small screw lines were first used. These were followed by leaded-joint lines, which type of connection in turn developed into the rubber-gasket joint of the present day. Welded lines have also been employed. In his paper Mr. Brock outlines the development of these various methods of constructing pipe lines, giving in connection therewith the results of tests made to determine their relative strength and reliability.

McCook Field and American Aeronautics, By Leon Cammen, New York, N. Y.

During the war McCook Field was the center of the engineering activities of the Army Air Service and as such it was the scene of great developments in the art and science of aeronautics. The chief work in the development of the Liberty motor, for instance, was carried on at McCook Field, and now, even though there is less activity at this aeronautical Detroit of the United States, the character and importance of the work carried on is as great as ever. In his paper Mr. Cammen traces the inception of the great flying field and describes the nature of the work now being done there. Chief among the problems which now claim the attention of the aeronautical engineers are those concerned with the variable-pitch propeller, the development of suitable aeronautical instruments, and research growing out of flight at high altitudes. All of these are discussed in a practical manner by Mr. Cammen. McCook Field as it now stands represents a powerful stimulus to the development of aeronautics in this country, and it is unquestionably destined to play a large part in the advancement of that art.

The Engineer and the Woodworking Industry, By Thomas D. Perry, Grand Rapids, Mich.

The woodworking industry is one of the greatest in this country and one in which it might appear that the engineer took a prominent part. Such, however, is quite contrary to the actual facts in the case, for this great industry is urgently in need of engineering skill of the highest type. With a view of outlining the scope of the woodworking field and presenting some of the engineering problems involved therein, Mr. Perry, vice-president and manager of the Grand Rapids Veneer Works, has prepared an article which appears in this issue. He discusses the problems involved from the conversion of timber and logs into lumber until that lumber finally appears in its finished form as furniture, house trim, caskets, pianos, etc. The paper does not purpose to be an exhaustive presentation of this vital subject, but merely a statement of facts.

An Investigation of Compressed-Spruce Pulleys, By George S. Wilson, Seattle, Wash.

To the current number Professor Wilson, of the University of Washington, has contributed a paper outlining the results of a research on the practicability of manufacturing pulleys from native spruce. In conducting the research special attention was given to a determination of the factors influencing the carrying capacity of compressed-spruce pulleys and a comparison of such pulleys with other commercial types. The paper contains curves and tables and a brief description of the method of conducting the tests.

MECHANICAL ENGINEERING

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 42 August 1920 Number 8

Metal Castings[1]

A Group of Papers on the Usefulness and Limitations of Various Types of Castings Contributed by the A. S. M. E. Sub-Committee on Foundry Practice

MECHANICAL engineers are called upon to decide or advise on the selection of the proper kind of casting for a given piece of construction and should therefore have available reliable information as to the present state of the art in foundry practice. The following papers are intended to outline the special properties of the particular kinds of casting of which they treat and to explain where they are to be preferred to other forms of cast metal. They also review what is actually being done so that engineers and designers may know what they should be able to secure from first-class commercial foundries at the present time. In the preparation of the papers the endeavor has been to avoid giving information on the art of making castings, the specifications or methods of testing castings or the production of the metals from which the castings are made.

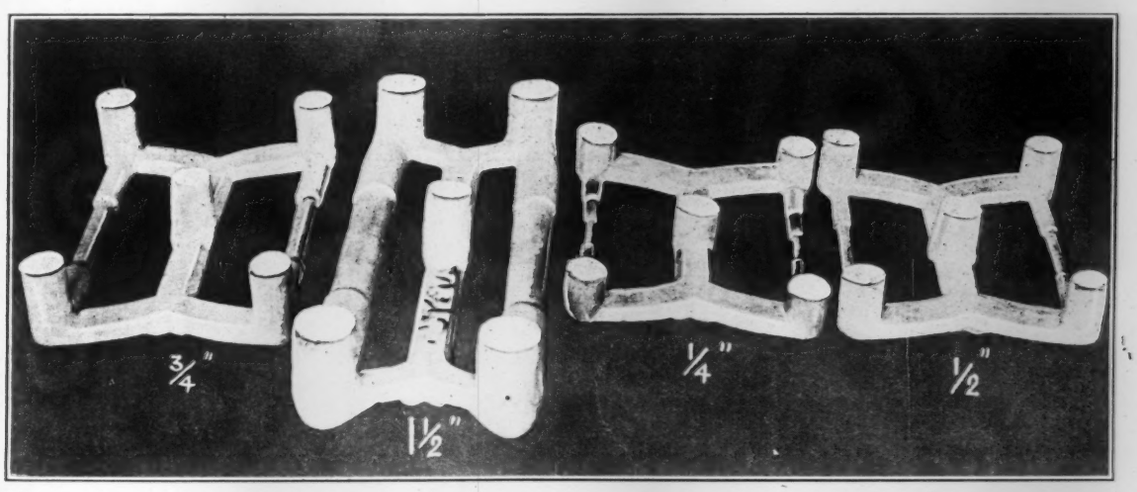


FIG. 1 METHOD OF CASTING ROUND TEST BARS OF VARIOUS DIAMETERS

ALUMINUM CASTINGS

By ZAY JEFFRIES,[2] CLEVELAND, OHIO

THE aluminum-castings industry can hardly be said to be more than fifteen years old. It is true that castings were made prior to 1905, but in such small quantities as to be insignificant in comparison with the present magnitude of the industry. The annual production of aluminum at the present time is about three hundred million pounds. The percentage of this used in castings is not definitely known, but it is estimated at about one-half the world's production.

The aluminum-casting art has developed largely by rule-of-thumb methods and even as recently as 1917 the quality of castings was so uncertain that aeroplane manufacturers and aviators had to be reassured of the reliability of the metal for aeroplane construction. In May, 1917, at the request of Messrs. Manley and Cardullo of the Curtiss Aeroplane Company, an investigation was made of the properties of aluminum castings then being used for aeroplane crankcases and other parts. It was found that the quality was very poor, the physical properties being neither uniform nor sufficiently high.

Immediate steps were taken to introduce technical control in the foundries to insure against wrong metal compositions and abuse of metal during the melting operations, and also to insure the maintenance of the proper pouring temperature. The results were very satisfactory, as is evidenced by the production record of Liberty engine castings in which a minimum tensile strength of 18,000 lb. per sq. in. was specified and the rejection for failure to pass specifications was practically nil. Even in such highly stressed parts as those in the Liberty engine, no failures in service have come to the author's attention.

ALUMINUM ALLOYS FOR CASTINGS

The principal aluminum alloy used for castings in the United States consists of about 92 per cent aluminum and 8 per cent copper and is generally known as Aluminum Company of America's No. 12 alloy or S. A. E. specification No. 30. This alloy when cast in a ½-in. test bar in green sand and tested without machining off the skin should give an average tensile strength of about 20,000 lb. per sq. in. and an average elongation of about 1.5 per cent in 2 in. A modification of this alloy having somewhat better physical properties is now finding considerable favor in castings for the automotive industry. This alloy has an analysis of 7.5 per cent copper; 1.5 per cent zinc; 1.2 per cent iron, and the remainder aluminum. The tensile strength of this alloy will average about 21,000 lb. per sq. in. and the elongation will be somewhat greater than that of No. 12 alloy.

[1] Abstracts of papers presented at the Castings Session of the Spring Meeting, St. Louis, May, 1920, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. All papers are subject to revision.

[2] Director of Research Laboratory, Aluminum Castings Company, Cleveland, Ohio.

S. A. E. Specification No. 32 is another alloy of aluminum and copper which finds considerable use, especially in parts which need to be water-tight. This alloy contains from 11 to 13.5 per cent copper, the remainder being commercial aluminum.[1] Its tensile strength when the test bar is cast in green sand about ½ in. in diameter and broken without machining off the skin should show an average of 20,500 lb. per sq. in. and the elongation will be practically nil. This alloy is used for carburetors, pumps, manifolds, radiators, engine cylinders, etc.

Another aluminum-copper alloy containing about 5 per cent copper is used for cast automobile bodies. This alloy has an average tensile strength of about 18,000 lb. per sq. in. and an average elongation of 3.0 per cent.

specific gravity of this alloy is 3.0 and its tensile strength when cast in sand should be over 25,000 lb. per sq. in. and the elongation should exceed 1 per cent. In England the test bars of this alloy are cast in chill molds and the minimum physical-property requirements are a tensile strength of 11 long tons (24,640 lb.) per sq. in. and an elongation of 4 per cent. This alloy is used in England as a substitute for our No. 12 alloy.

An alloy containing 10 per cent zinc and 2.5 per cent copper is put out in ingot form in England by the British Aluminum Company. This alloy should have a tensile strength of more than 22,000 lb. per sq. in. and an elongation of more than 2 per cent in 2 in.

Aluminum Manufactures, Inc., use an alloy containing 7 per

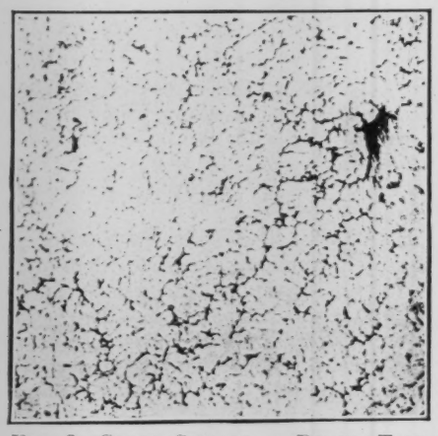


FIG. 2 GRAIN SIZE IN A ROUND TEST BAR OF 8 PER CENT COPPER ALLOY, 1¼ IN. IN DIAMETER, CAST IN GREEN SAND. MAGNIFICATION 50 DIAMETERS

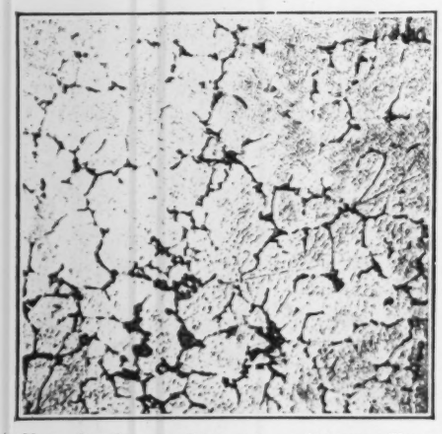


FIG. 3 GRAIN SIZE IN A ROUND TEST BAR OF 8 PER CENT COPPER ALLOY, 1½ IN. IN DIAMETER, CAST IN GREEN SAND. MAGNIFICATION 50 DIAMETERS

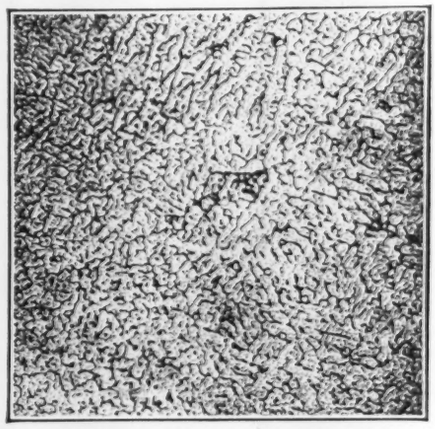


FIG. 4 MICROGRAPH OF ALUMINUM ALLOY CONTAINING 8 PER CENT COPPER, SHOWING GRAIN SIZE PRODUCED BY CASTING CYLINDER 1¼ IN. DIAM. IN GREEN IRON MOLD. MAGNIFICATION 50 DIAMETERS

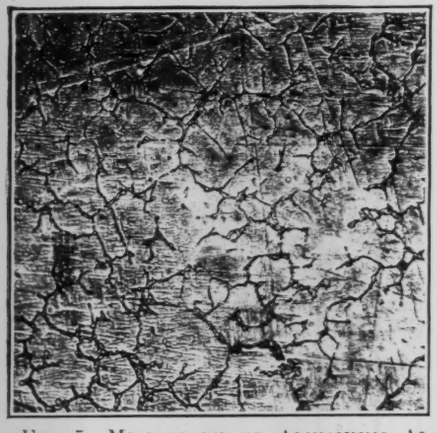


FIG. 5 MICROGRAPH OF ALUMINUM ALLOY CONTAINING 8 PER CENT COPPER, SHOWING GRAIN SIZE PRODUCED BY CASTING CYLINDER 1¼ IN. DIAMETER IN GREEN SAND. MAGNIFICATION 50 DIAMETERS

FIG. 6 SPECIMEN SHOWN IN FIG. 4 BUT AT HIGHER MAGNIFICATION TO SHOW STRUCTURE OF NETWORK SURROUNDING THE GRAINS. MAGNIFICATION 250 DIAMETERS

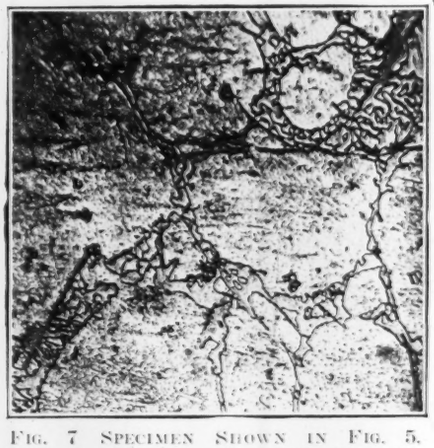


FIG. 7 SPECIMEN SHOWN IN FIG. 5, HIGHER MAGNIFICATION BRINGS OUT THE STRUCTURE OF THE NETWORK AROUND THE GRAINS. MAGNIFICATION 250 DIAMETERS

For pistons cast in permanent molds an alloy containing 10 per cent copper, 1.25 per cent iron, 0.25 per cent magnesium is extensively used. This alloy gives a good wearing surface both for the piston against the cylinder wall and for the bearing of the wristpin in the bosses. The pistons and camshaft bearings for the Liberty engine were made from this alloy, the former being cast in permanent molds.

While the aluminum-copper alloys have been used mostly in the United States, light alloys containing zinc have been used more extensively abroad. The most common alloy in use in England for sand castings contains 13.5 per cent zinc and 2.75 per cent copper, the remainder being commercial aluminum. The

[1] Commercial aluminum always contains iron and silicon in amounts of 0.25 per cent and upward according to the grade of ingot.

cent zinc, 2.75 per cent copper and 1.5 per cent iron. This alloy has an average tensile strength of about 27,500 lb. per sq. in. when cast in green sand and an average elongation of about 4.5 per cent.

Zinc is added to aluminum up to 33 per cent. As the zinc increases up to this amount the tensile strength increases and the elongation decreases. The 33 per cent zinc alloy has been used considerably in the past but it is too brittle to find extensive employment in the industries in competition with more ductile alloys which also have lower specific gravities.

At the Westinghouse Electric and Manufacturing Company an alloy composed of 95 per cent aluminum and 5 per cent magnesium is used for starting-motor frames and other automobile work where extreme lightness and good machining qualities are

essential. The specific gravity of this alloy is 2.47, the average tensile strength about 27,000 lb. per sq. in., and the elongation about 3 per cent.

At the United States Navy Yard, Washington, D. C., an alloy containing 2 per cent copper and 1 per cent manganese is used for all aluminum-casting work. It is used for parts for gun sights, optical instruments, loading-tray sights for naval mounts, mine-laboratory experimental work, parts for nitrating machinery for use in the manufacture of powder, etc. This alloy has a tensile strength of about 18,000 lb. per sq. in. and an elongation of about 8 per cent. Its proportional limit is very low, often not exceeding 2000 lb. per sq. in.

An alloy containing 98 per cent commercial aluminum and 2 per cent manganese is also used for certain aluminum castings which should resist the corrosive action of chemicals used in rubber molding.

Physical Properties of Aluminum and Its Alloys

Hardness. The Brinell hardness of pure aluminum is about 25 and that of the hardest aluminum alloy is more than 120. Where hardness is the controlling factor, any value between 25 and 120 can be produced.

Coefficient of Expansion. The coefficient of expansion of pure aluminum is about 0.000025 per deg. cent. The coefficient of expansion of the alloys varies between 0.000022 and 0.000027. Alloys containing about 5 per cent magnesium have the higher coefficient of expansion and the high-copper alloys show the lower values.

Heat Conductivity. The heat conductivity of pure aluminum is about 0.50 *K* or about 48 per cent of the conductivity of copper at ordinary temperatures, and varies but slightly with temperature. The heat conductivity of aluminum alloys is less than that of the pure metal, varying between 25 per cent and 48 per cent of the conductivity of copper, the general rule being that the greater the percentage of alloying elements, the lower the heat conductivity.

Electrical Conductivity. The electric resistivity of pure aluminum is about 2.94 microhms per cubic centimeter. The electric resistivity of the alloys is higher than that of pure aluminum, ranging up to 5.70 microhms per cu. cm.

Melting Points. The melting point of pure aluminum is 658 deg. cent. The lowest melting points of the useful alloys range around 580 deg. cent.

Crystallization Shrinkage and Allowance for Pattern Shrinkage. The crystallization shrinkage of pure aluminum is about 5 per cent by volume, and a further 5 per cent decrease in volume takes place on cooling from the melting point to room temperature. The crystallization shrinkage is somewhat less in the alloys. The pattern shrinkage allowed for all aluminum alloys is 5/32 in. per ft.

Specific Gravity. The specific gravity of pure aluminum is about 2.7 and that of the alloys is not far from that calculated from the specific gravities of the various constituents. An alloy containing 95 per cent aluminum and 5 per cent magnesium has a specific gravity of about 2.47 and one containing 67 per cent aluminum and 33 per cent zinc a specific gravity of about 3.3. These represent minimum and maximum values for the usable aluminum-base alloys.

Modulus of Elasticity. The modulus of elasticity of aluminum is about 10,000,000 lb. per sq. in. Values as low as 8,500,000 and as high as 11,000,000 have been obtained.

General Observations on Aluminum Castings

Classes. Aluminum castings may be divided into three classes according to the method of manufacture, namely,

1 Sand Castings
2 Permanent Mold Castings
3 Pressure Die Castings.

Sand castings are so named because they are cast in either green or dry sand. The method of molding is very similar to that used for other metals except that the gates, risers and chills must be used to suit the particular properties of aluminum and its alloys. Such parts as crankcases for gas engines, oilpans, manifolds, steering-wheel spiders, transmission housings, differential carriers, etc., are usually cast in sand.

Permanent-mold castings are made in iron or other metal molds and consequently have a greater degree of chill than the sand castings. The physical properties of the various alloys vary in proportion to the degree of chill. Molds for the permanent-mold castings are provided with ample gates and risers for feeding, consequently the permanent-mold casting is non-porous as distinguished from the pressure die casting, which is always porous in the interior. As a general rule the permanent-mold process is limited to small parts with simple shapes.

Pressure die castings are considered in a paper on Die Castings presented at this session by Mr. Charles Pack.

Maximum and Minimum Weight. Aluminum sand castings have been regularly made weighing as high as 480 lb. each, but one of 150 to 200 lb. is usually considered a large casting. The

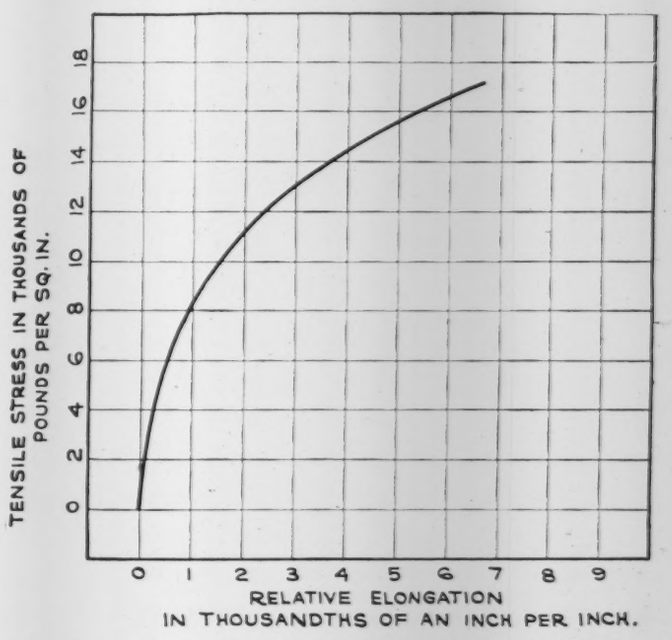


Fig. 8 Stress Strain Diagram of Alloy Containing 92 Per Cent Aluminum and 8 Per Cent Copper

minimum weight may be taken as 1 oz., but neither this weight nor 480 lb. should be considered as an extreme limit.

In the permanent-mold process the maximum weight is about 20 lb. and the minimum weight about 1 oz. Permanent-mold castings have been made weighing as high as 150 lb. but these large castings should be considered as special.

Section Thickness. On gas-engine oilpans the walls should be 3/16 in. or more in thickness and on crankcases a wall thickness of 7/32 in. or greater is common practice. Fillets should have large radii, especially where heavy sections join thin sections. The best thickness on pipes, manifolds, etc., is 1/8 to 5/32 in. The minimum thickness on permanent-mold castings is from 3/32 in. to 1/8 in.

Finish. On large sand castings 1/8 in. should be allowed for finish and on bench work 1/16 in. A finish of 1/32 in. should be allowed for disk grind.

The finish on permanent-mold castings up to 3 in. in diameter, for example, pistons, should be about 0.075 in. on the diameter, and the finish on the piston head should be 0.045 in. The finish on permanent-mold pistons over 3 in. in diameter should be about 0.093 in.

Tolerances on Dimensions and Weights. In sand castings a tolerance of 1/32 in. in thickness should be allowed and in permanent-mold castings the tolerances are plus or minus 0.010 in. The weight tolerances on sand castings using metal-pattern equip-

ment are plus or minus 3 per cent and with wood patterns plus or minus 5 per cent. The weight tolerances on permanent-mold castings are plus or minus 2 per cent.

Machining. For roughing cuts speeds of 500 to 700 ft. per min. and a feed of $\frac{1}{16}$ in. to 5/32 in. are recommended, according to the nature of the work. No lubrication is recommended for roughing. For extra fine finish a speed of about 125 ft. per min. is recommended, but speeds up to 600 ft. can be used and satisfactory finish obtained. For turning, the finishing feeds should be from 0.01 in. to 0.125 in., and for planing, up to 0.25 in. A good lubrication mixture for finishing is 70 parts kerosene and 30 parts lard oil.

Aluminum alloys take a fine finish by grinding. Good results have been obtained using a No. 40 grain crystolon wheel and a mixture of 10 per cent lard oil and 90 per cent water for lubrication. The grains of the crystolon wheel even when dislodged do not stick in the metal.

Heat Treatment of Aluminum-Alloy Castings

Aluminum castings, especially those containing copper, may have their volumes permanently changed by heat treatment. Also the hardness may be changed. These facts are taken into consideration in connection with the heat treatment of aluminum-alloy parts such as pistons which will have to operate at an elevated temperature. The pistons are given a heat treatment which will cause permanent growth to such an extent that no additional change of volume will take place during normal running.

Effect of Thickness of Section on Physical Properties of Aluminum Alloys

In general, the tensile strength and elongation of the aluminum alloys decrease as the thickness of the section increases. In the case of round test bars cast as shown in Fig. 1, the decrease in tensile strength in an alloy containing 8 per cent copper and 92 per cent aluminum is from approximately 25,000 lb. per sq. in. and 3 per cent elongation in the ¼-in. test bar, to 14,000 lb. per sq. in. and less than 1 per cent elongation in the 1½-in. test bar, with proportional intermediate values for the ½-in. and ¾-in. bars.

It appears that this alloy on account of its low elongation does not show up so well when tested in a large piece as would be indicated from the results obtained from small test bars machined from the larger pieces. For example, small test bars cut from the 1½-in. bars averaged about 19,000 lb. per sq. in. and the elongation was more than 1 per cent, whereas the large bars tested 14,000 lb. per sq. in. and less than 1 per cent elongation. The tensile strength of one of the zinc alloys described earlier decreases at an approximately linear rate from about 30,500 lb. per sq. in. in a ¼-in. test bar to 19,500 lb. in a 1½-in. test bar. Small bars cut from the 1½-in. bar tested about the same as the 1½-in. bar itself. The elongation of the zinc alloy decreases also with increase in thickness of section. It is thought that the greater ductility of this alloy is responsible for the similarity of results between the small test bars cut from the large bars and the large bars themselves.

The lower strength and ductility of the large sections are due to a combination of variation in grain size and soundness of the casting. The smaller sections are as a rule better fed during solidification and since they solidify more rapidly than the thicker sections, they are also finer-grained. Figs. 2 and 3 show the variation in grain size in the 8 per cent copper alloy when cast in ¼-in. and 1½-in. bars.

Effect of Rate of Chill on the Physical Properties of Aluminum Alloys

As a general rule, the more quickly aluminum alloys solidify the smaller the grain size and the higher the tensile strength and elongation. No. 12 alloy, for example, when cast in large sections in sand may have a tensile strength as low as 14,000 lb. per sq. in. and an elongation of less than 1 per cent. When cast in small sections in a chill mold its tensile strength may be 31,000 lb. per sq. in. and its elongation as high as 6 per cent. Figs. 4, 5, 6 and 7 show the effect of degree of chill on the structure of an alloy containing 92 per cent aluminum and 8 per cent copper.

Fatigue Resistance of Aluminum Alloys

In sand-cast bars of No. 12 alloy the fatigue resistance as measured on the White-Souther machine is about 14,000 lb. per sq. in. maximum stress for 500,000 reversals and about 8500 lb. per sq. in. maximum stress for 16,000,000 reversals. The proportional limit of this alloy is about 5000 lb. per sq. in. The stress-strain curve departs very gradually from a straight line after the proportional limit is exceeded, as is shown in Fig. 8. It is believed that the proportional limit of the aluminum alloys does not represent a breakdown of the main metallographic constituent as in a single-component metal like wrought iron, but that it simply breaks some of the unfavorably situated, brittle aluminum compounds and thus causes slight permanent set. The fatigue life of the aluminum alloys is quite unusual, inasmuch as the safe limit seems to be equal to or higher than the proportional limit as measured by the extensometer. Chill-cast alloys are even better than the sand-cast alloys for fatigue resistance.

In a very comprehensive paper entitled Aluminum Alloys for Aeroplane Engines, by Prof. F. C. Lea, published by the Royal Aeronautical Society in 1919, fatigue tests on various aluminum alloys are reported, together with stress-strain diagrams. These tests show a minimum fatigue range in the Wohler test of 12,000 lb. per sq. in. (— 6000 to + 6000) for 12,000,000 reversals on an alloy containing 12 per cent copper. The proportional limit of this alloy was 5000 lb. per sq. in., although the amount of permanent set up to 6000 lb. was very slight.

General Considerations Regarding Use of Aluminum Castings

As an engineering metal aluminum is in a class by itself because of its low specific gravity. Its use is determined by many factors, among which are the following:

a Where lightness is of prime importance. Aluminum in sheet form has about seven times the stiffness of steel for equal weights. For a given rigidity in any metal structure aluminum will weigh less than any other metal used in engineering. For such parts, therefore, as aeroplane engine crankcases, camshaft housings, oil-pans, etc., where lightness and rigidity are of prime importance, aluminum alloys find extensive use.

b In the manufacture of gas-engine crankcases it is found that the aluminum castings can be machined about three times as rapidly as cast-iron parts, and consequently the first cost of plant installation and labor cost of machining is greatly decreased by the substitution of aluminum for cast iron. The lightness of the crankcase is the chief advantage because the weight of the engine per horsepower is reduced.

c Where the lightness of reciprocating parts, like pistons, is of great moment, such as in high-speed gas engines, the use of aluminum is very beneficial. The aluminum piston also has the advantage of high heat conductivity, which is sometimes of greater importance in a gas engine than reduction in weight.

d For reducing unsprung weight in motor vehicles, aluminum is particularly valuable. This includes such parts as differential carriers, rear-axle housings, brake shoes, hub caps, wheels, etc.

e Aluminum alloys, especially with moderate pressures, function nicely as bearings against hardened steel. As an example, the Liberty Engine camshaft was run in aluminum bearings, as were also the rocker arms. Aluminum alloys, however, do not bear well against soft steel.

f For equal volumes aluminum is cheaper than brass or bronze. Aluminum alloys find extensive use as a substitute for brass and bronze castings where freedom from atmospheric corrosion is of prime importance and where the strength requirements are not too severe.

Selection of Alloy

For aluminum castings not highly stressed, No. 12 alloy should be used. Where freedom from leaks is the main requirement, the 12 per cent copper alloy is good and the more-ductile zinc alloy

should be used for highly stressed parts. Present-day engineering materials are required to stand abuse rather than normal use. Ductility is essential if an alloy is to stand abuse, and this is the main reason for the use of the aluminum alloy containing 2.75 per cent copper, 1.5 per cent iron and 7 per cent zinc.

[The complete paper includes a brief discussion of the metallography of aluminum alloys, and of the aging of aluminum-alloy castings.—EDITOR.]

MALLEABLE CASTINGS

BY ENRIQUE TOUCEDA[1], ALBANY, N. Y.

IN general, the selection of the proper kind of a ferrous casting for use in a given piece of construction is dependent upon a number of considerations, chief among which may be mentioned the following:

a Ability to successfully withstand the abuse to which it will be subjected in service

b High static and dynamic strength, which implies minimum sections for the strains involved, this in turn implying low cost for raw castings, as such are not only less costly in direct proportion to their strength, but their appearance is enhanced thereby

c Ease of machining, accompanied by a good surface on faced and turned parts, and freedom from unsoundness; which implies beauty of finished castings and low cost due to less loss from defective castings

d Smoothness of surface and trueness to pattern.

In discussing the foregoing a fact should be remembered that is frequently overlooked, viz., that the gray-iron, the malleable-iron and the steel casting have each a legitimate field of their own quite sharply defined by virtue of certain peculiarities possessed by each particular product. If a bedplate is desired for a certain large and ponderous machine, so dimensioned as to possess sufficient mass to enable it to absorb vibration, it would be unwise to specify that it be made of malleable cast iron. The malleable-iron founders are not at the present time equipped to cast and anneal castings of such size, and as cheapness and weight—obviously not high strength per square inch—are the dominant requirements in this case, the malleable-iron casting should not be specified. The same remarks hold good in the case of the steel casting, except of course that it is practical to make such castings as large as any made of gray iron.

GRAY-IRON CASTINGS VS. MALLEABLE-IRON CASTINGS

The truly legitimate field of gray iron, in the writer's opinion, should and will in time be restricted to the production of that size of casting that cannot successfully be produced in malleable iron and is too costly to produce in steel, while it is peculiarly well fitted for such castings as are designed to sustain static compression, for which purpose the gray-iron casting is without question superior to either of the other two. The average ultimate tensile strength of the gray-iron casting as measured by the test bar does not exceed 20,000 lb. per sq. in., while it possesses practically no ductility. The writer can state with positiveness that in the case of at least sixty of the malleable-iron foundries the average ultimate strength and elongation of their product, as measured by the standard test bar, are 51,000 lb. and 12.50 per cent, respectively.

It can safely be stated that if a gray-iron and a malleable-iron casting are designed to perform the same function, the design of each being based strictly upon its physical properties, in view of the great difference in their relative strengths, coupled with the fact that a larger safety factor must be used in the case of the former due to its inherent brittleness, the latter can safely be made more than one-third lighter. Inasmuch as this difference in weight will in large measure counterbalance the difference in cost per pound with the substitution of a ductile casting for one that is brittle and is actually more easy to machine, the writer believes that when this fact is fully understood and its significance appreciated, many castings now made of gray iron will be replaced by malleable, with the result that the gray-iron-casting field will of necessity be narrowed to this extent. It is therefore logical to conclude, as between these two products, that if the part can be successfully cast of malleable iron, the following statements hold true:

a For equal physical properties it is as cheap per raw casting

b It is as cheap per machined casting

c It will have a more pleasing appearance when assembled

d It will be lighter in weight

e Transportation charges will be less

f The weight per square foot on the floor will be less

g Breakage during transportation will be eliminated.

STEEL CASTINGS VS. MALLEABLE-IRON CASTINGS

If the same line of reasoning be used as between the malleable iron and the steel casting, it can be stated at the start, that neither can successfully trespass in certain directions in the field of the other, for each, as will be explained, has certain limitations that control the situation. There is hardly a limit to the size or weight in which the steel castings can be made, while as previously pointed out there is a limit in the case of malleable iron. On the other hand, there are castings that can be very nicely made of malleable iron that cannot well be made of steel, using the same pattern.

The American Society for Testing Materials standard specifications for steel castings deal with two classes: Class A, for which chemical but no physical requirements are specified and which need not be annealed unless so specified; and Class B, which is divided into three grades, hard, medium, and soft, it being specified that all of these grades shall be properly annealed, and also conform to certain chemical and physical requirements. While the ultimate strength of both Class A castings and the soft grade of Class B castings may average higher than that of malleable iron, their yield point will average lower by some 4000 lb. Consequently for equal stiffness the malleable-iron casting has an advantage in the case of equal sections.

Inasmuch as the A. S. T. M. specification for Class A castings states that they need not be annealed unless so specified, it is to be expected that the majority of these castings do not receive that treatment. This means the presence of internal strains in such castings, minimized to a certain extent, however, if baked molds are used. The writer knows of quite a number of large steel-casting companies that turn out a large daily tonnage of castings that are never annealed and assumes that in such cases they are made in accordance with specifications other than those of the A. S. T. M., and after considerable inquiry he has come to the conclusion that 70 per cent of the steel castings produced in this country are not annealed.

It happens that the heat treatment given the malleable-iron casting during the period in which the white iron is being converted into the malleable product, is carried on at a temperature just slightly in excess of the critical range, a temperature which yields practically the finest crystallization that the metal can attain, while the cooling from this temperature is effected at the rate of about ten degrees per hour. In consequence of this the malleable-iron casting is not only fine-grained but is invariably free from internal strains. On the other hand, not only are unannealed steel castings in a state of internal strain, but they possess a coarsely crystalline structure corresponding to the temperature of solidification. In view of all this, the writer believes that if a given casting be made of malleable iron it will stand more abuse in service than will a similar unannealed steel casting.

If the cost of the raw casting is the dominant factor, then unquestionably preference must be given to the malleable-iron casting, as the difference in cost is considerable. If based upon the cost of the finished casting, the difference between the cost of the two will be much greater, due to the greater ease with which the malleable casting can be machined, which difference will vary directly in proportion to the amount and character of the machining operations.

[1]Consulting Engineer.

The malleable-iron casting is characteristically free from blowholes, while this is acknowledged to be one of the shortcomings of the steel casting; consequently, there will be less scrap in the case of the former. If rust-resisting properties are a consideration, as in the case of castings for refrigerator cars, the malleable-iron casting should be given preference over steel.

Properties and Limitations of Malleable-Iron Castings

In commercial practice the engineer who has placed his contract with a reliable foundry can depend upon a uniformity of product that will rarely have a yield point lower than 31,000 lb. per sq. in. and frequently as high as 33,000, an ultimate strength less than 50,000 lb., or an elongation less than 10 per cent. He can quite safely depend upon the integrity of the casting, for the reason that the founder has finally learned through costly experience that freedom from shrinkage depends not only upon correct gate emplacement, but more particularly upon the use of large shrink heads, so located as to eliminate such defects. Castings have been produced commercially as long as 5 ft., with sections at some parts as thick as 3 in. In regular practice castings varying in weight from 300 to 500 lb. are made daily, while it would be difficult to place a limit on how small they can be run.

The wearing properties of this metal correspond to what can be expected of wrought iron or dead soft steel, while as is well known its machining properties can hardly be excelled. As far as the ordinary uses of malleable cast iron are concerned, the writer feels quite certain that no beneficial results can follow from its heat treatment. In a limited number of cases, however, such as in the production of cheap hatchets, cleavers, and axes, malleable iron can be made file-hard by heating to just above the critical range and quenching.

Comparative Costs of Gray-Iron, Steel and Malleable-Iron Castings

A general statement relative to the comparative cost of manufacture of the three products mentioned must obviously involve the consideration of many different cases and conditions. If it were not for the fact that in the case of the manufacture of malleable iron the annealing (which lasts from six to seven days and is a rather costly part of the process) must be taken into account, an approximate estimate could be made by figuring out the cost of the metal in the ladle for each of the three products; but the varying cost of molding in each case and the fact that the sprue can be easily knocked off from both gray and malleable-iron castings while it must be machined or cut off from the steel casting, render it rather difficult to make a comparison of the costs of the raw castings. In general, however, gray-iron castings run heavier than do those made of malleable iron. Consequently there is less sprue and therefore less remelt. Also there is less variation between the composition of the sprue and that of the charge and as a consequence a much larger percentage of scrap can be used in the mixture when making gray-iron than is possible in the case of the malleable castings. Assuming the highest fuel ratio in each case, 10 of iron to 1 of coke for the cupola, and 3 of iron to 1 of soft coal in the air furnace, it will be seen that the cost for fuel is less in the former than in the latter case. The same holds true in connection with furnace maintenance. Aside from cleaning and clipping, the gray-iron casting is finished when the metal fills the mold, while the white-iron castings must be cleaned, taken to the annealing room, packed in saggars, and then charged into the annealing oven and heat-treated for a period in most instances of seven days. The saggars must then be removed from the annealing oven, the castings again cleaned and sorted, to the cost of which must be added that of the fuel used for heat treatment, oven maintenance, supervision, and overhead. It can therefore be very easily seen that there must be considerable difference between the cost of production of these two products. The writer believes that on an average it will easily cost 1 cent a pound more to produce malleable-iron than it will the gray-iron castings, and at least 30 per cent more to produce steel castings than malleable.

STEEL CASTINGS

By JOHN H. HALL,[1] HIGH BRIDGE, N. J.

THE more observing users of castings, having learned during the war that it is possible to produce a far better steel casting than had formerly been supplied, have in some cases profited by their recently acquired knowledge, and are demanding and securing the better product. The testimony of some of the very best makers of small steel castings, however, is to the effect that the buyers of their wares still adhere to their old practice of requiring first of all a freely machining casting and will not tolerate improvement in the quality of the steel if it interferes in the slightest with ease of machining. This attitude is unfortunate and really short-sighted, as in the long run it can have but one result. Those who maintain it are sure, sooner or later, to suffer from the competition of concerns making and machining their own castings, and willing to sacrifice a little to better quality. It is true at the present time that the very best steel castings made are used for the most part by those who make them, and for certain classes of product that are subjected to very severe service. Castings are now being made that show all-around physical properties nearly twice as good as those of the ordinary commercial steel casting, but the average machine-shop proprietor absolutely cannot be persuaded to use them, simply because they do not machine quite so freely as those he has been accustomed to in the past.

Range of Weight of Steel Castings Practically Unlimited

There are practically no limitations to the maximum and minimum weights of steel castings that can be produced commercially. The foundryman using a small bessemer converter, a crucible furnace or a small electric furnace can and does make castings with sections as light as $\frac{3}{8}$ in., and in some cases even $\frac{1}{4}$ in., provided their size and intricacy is not such as to make this impossible. On the other hand, the open-hearth furnace will pour castings as heavy as are ever called for, some poured in the last few years weighing 150 tons or even more, and with maximum sections of several feet. In fact, the steel foundryman is not so much concerned with the actual thickness of any particular section as with the combination of thick and thin sections in one and the same casting. When absolutely necessary, he can execute a casting of great intricacy in which thick and thin sections occur, often in exasperating combinations; but it is an undoubted fact that if the designer of castings would take counsel more often with the foundryman, he would obtain advice that would help him to secure a far better casting, and one that would more successfully meet the service it is called upon to stand.

Physical Properties of Steel Castings

The physical properties of the average commercial steel casting depend largely upon whether or not the casting has been annealed. Perhaps 50 per cent of the steel castings made in this country are shipped without annealing. This statement is not made on actual knowledge and is consequently subject to criticism as too high or too low, depending upon whether the critic is or is not a steel foundryman. The American Society for Testing Materials specifications for steel castings call for two classes, A and B. Class A castings "need not be annealed unless so specified." The carbon of these castings is specified not over 0.30 per cent, and the phosphorus not over 0.06 per cent (at present 0.07 per cent is allowed). Such castings will test about as follows:

Tensile strength, lb. per sq. in.	60,000
Yield point, lb. per sq. in.	25,000
Elongation in 2 in., per cent	10 to 15
Reduction of area, per cent	15 to 25

The A. S. T. M. specifications do not call for tensile or bending tests on Class A castings. These specifications are intended to cover only such castings as are not subject to very severe service, and in which the chief characteristics desired are soundness and comparatively easy machining.

[1] Taylor & Wharton Steel Co.

The writer is aware that some engineers are willing to accept unannealed steel castings for quite severe service, even for parts of locomotives and cars. The properties of the metal, as shown by the ordinary static tensile and bending tests, are considered good enough to justify the use of the unannealed steel. Of course the only steel so accepted is quite low in carbon, and accordingly fairly tough, at least in static tests.

From a fairly long acquaintance with cast steel, however, the writer is forced to state that in his opinion this policy cannot be justified. Our knowledge of endurance or "fatigue" tests teaches us that a coarsely crystallized metal such as unannealed cast steel cannot have a really high resistance to severe alternating stresses, and nothing like as high as the same metal will have after the coarse structure has been broken up by annealing and replaced by a finely crystalline condition.

It is when we come to consider resistance to sudden heavy shocks, however, that the danger of using unannealed cast steel for severe service strikes us most forcibly. Tests made by the writer have shown that under heavy shock cast steel even as low in carbon as 0.10 per cent breaks almost without bending, and with very little absorption of energy. In other words, the metal is truly brittle under impact test. After ordinary annealing the resistance to shock is greater, and the test piece bends through a greater angle before rupture. If the steel under test has been heat-treated by rapidly cooling and reheating, the shock resistance and angle of bend are increased to an even greater extent.

These tests were made on a Frémont testing machine; but the writer has made many tests on full-sized castings that amply justify him in his opinion that the use of unannealed cast steel for service calling for ability to resist sudden heavy shocks cannot be justified unless the sections of the piece can be made very heavy for the strength desired—in other words, unless weight per unit of strength can be disregarded.

The A. S. T. M. Class B castings must not exceed 0.05 per cent phosphorus or sulphur. (At present this has been temporarily increased to 0.06 per cent.) No other chemical specifications are given, the analysis other than phosphorus and sulphur being left to the judgment of the foundryman. Annealing, however, is specified. These castings are divided into three grades: Hard, Medium, and Soft, which must give physical properties as follows:

	Hard	Medium	Soft
Tensile strength, lb. per sq. in.	80,000	70,000	60,000
Yield point, lb. per sq. in. (=0.45 T. S.)	36,000	31,500	27,000
Elongation in 2 in., per cent	15	18	22
Reduction of area, per cent	20	25	30
Cold bend around 1-in. pin, deg.	..	90	120

Reliable foundries can meet these specifications with practically no trouble beyond the expense necessarily due to meeting the requirement that castings be kept together by heats as poured, and the cost of making the test specimens and carrying out the tests. Most specifications as now written call for so many test pieces that the cost of producing the castings is considerably increased. This is particularly true when it is specified that a test shall be attached to each and every casting over a certain weight. The writer has known cases in which this specification was literally insisted upon where as many as fifty almost identical tests were pulled from a heat of open-hearth steel. The A. S. T. M. specifies a test attached to every casting weighing over 500 lb. unless the sections are such that a satisfactory test piece cannot be attached to it. In that case, and for castings under 500 lb., two test bars may be cast to represent a heat, or "in the case of small or unimportant castings, a test to destruction on three castings from a lot" may be used. This test shall show the material to be "ductile, free from injurious defects, and suitable for the purpose intended." This provision for testing small castings to destruction in place of using test bars is an excellent one and should be used more than it is.

Annealing and Heat Treatment

In order to meet specifications similar to those of the A. S. T. M., annealing is essential. The annealing practice followed is almost invariably such as to give the castings the greatest possible softness and ease of machining, and no heat treatment as the term is usually interpreted is needed to meet these specifications if the steel is well made in the first place. Castings annealed in this manner should machine very freely or fairly freely, depending upon whether they are of "soft" or "hard" grade, as prescribed. If the first cut is deep enough to get well under the scale left by annealing and if the casting is free from adhering sand, it should give no trouble in machining.

Heat treatment as usually understood, that is, annealing the castings at a proper temperature, cooling more or less rapidly, and then heating a second time, produces castings with very much better physical properties than those of plain annealed cast steel, and at the same time produces a somewhat harder and much-finer-grained steel which has far better wearing qualities and much better resistance to fatigue than is possible in the case of castings which are simply annealed. In extreme cases, by using heat treatment and special analysis, it is possible to produce castings that will show as good tensile strength as "Class B Hard" of the A. S. T. M. specifications, and equal or exceed the elongation, reduction of area and bend of "Class B Soft" castings. The yield point especially is raised by heat treatment, and the wearing properties are improved. The resistance to fatigue is also greatly increased, and, most important of all, the power to resist sudden shock is enormously improved.

The cost of such heat treatment, if substituted for plain annealing when the castings are made, need not be higher than that of plain annealing, provided the foundry is properly equipped to carry out heat treatment. It must be confessed, however, that the average foundry today is not so equipped, and in many cases does not have on its staff a man who thoroughly understands heat treatment. In the writer's opinion this state of affairs is due as much to the buyer of castings as to the maker, because the buyer as a rule is not at all interested in the superiority of heat-treated or special-analysis steel castings, as soon as he finds that such castings machine a little less freely than the common variety. The writer has had violent protests from customers because some of his castings gave a long, curling chip in the lathe, as a forging does, instead of the usual crumbly chip of the common steel casting, and the fact that the physical properties of the castings were about as follows:

Tensile strength, lb. per sq. in.	85,000
Yield point, lb. per sq. in.	55,000
Elongation in 2 in., per cent	25
Reduction of area, per cent	50
Cold bend around 1-in. pin, deg.	180

did not interest the customer in the least; and yet he had come to the foundry in which the writer was employed, and asked particularly for a casting to resist extremely severe fatigue and shock!

Cost of Steel Castings

The cost of steel castings, of course, varies with the size, weight and intricacy of the pattern to be executed. At the present time heavy castings such as are suitable for production in open-hearth foundries can be obtained for from 8 cents per lb. up, depending upon the difficulty of the job, while small and difficult castings command a price of about 12 cents per lb. up. No upper limit for price can very well be given, as very small or difficult castings, on which a piece price is often quoted, may go as high as $1.00 per lb. or even higher; but the foregoing figures are close enough for comparative purposes.

Where Steel Castings Should Be Specified

Steel castings should be used for all cases where a forging is not suitable or is prohibitive in cost, and where the service to be rendered calls for strength and toughness combined. To enumerate the uses of steel castings would be virtually impossible. It is enough to say that cast iron is suitable for service in which the stresses are chiefly compressive, or where the stresses to be endured can be taken care of by increasing the size of the casting, regardless of the resulting weight. In fact, in many cases where cast iron is used, as in bed plates of engines and heavy machines, great weight for a given strength is even desirable. Where moderate strength and toughness, combined with fairly good resistance to

wear and fatigue, are desired, a malleable-iron casting is plenty good enough. When, however, the service demands all the strength, toughness, and resistance to wear and fatigue that are obtainable in a cast metal, a steel casting should be specified; and if the service is unusually severe, the engineer should use the best cast steel he can buy, and should not allow himself to be influenced in his choice by the fact that the metal does not machine as freely as inferior cast steel or malleable iron.

DIE CASTINGS

By CHARLES PACK,[1] BROOKLYN, N. Y.

DIE CASTINGS may be defined as castings made by forcing molten metal, under pressure into a metallic mold or die. It is erroneous to assume that all die castings have similar properties, since it is apparent that the properties of the die casting will depend upon the nature of the alloy used. The die-casting process is best adapted to alloys of comparative low fusing points which may, for convenience, be divided into the following groups:

Group A Zinc Alloys, consisting essentially of zinc alloyed with tin, copper or aluminum

Group B Tin Alloys, consisting essentially of tin alloyed with copper, lead or antimony

Group C Lead Alloys, consisting essentially of lead alloyed with tin or antimony

Group D Aluminum Alloys, consisting essentially of aluminum alloyed with copper.

No general rules can be laid down governing the design and application of die castings since the art depends largely upon the skill of the designers, and quite frequently a part may be considered as impractical from a die-casting standpoint which, if measured by given standards, may be redesigned and die-cast very successfully. Nevertheless the writer will endeavor to outline briefly the general properties of the alloys used, their fields of application and their limitations.

GROUP A—ZINC ALLOYS

Typical Alloy:

Zinc	87.5 per cent	Copper	4.0 per cent
Tin	8.0 per cent	Aluminum	0.5 per cent

Properties:

Color	Silver white
Weight per cu. in.	0.253 lb.
Melting point	780 deg. fahr.
Initial fusing point	275 deg. fahr.
Tensile strength	16,100 lb. per sq. in.
Elongation	2 per cent
Compressive strength	27,670 lbs.
Pressure required to shorten bar 1 in. diameter	10 per cent
Hardness number (Brinell)	64.6

Casting Limits:

Maximum weight for casting	8 lb.
Minimum limit of wall thickness	1/10 in.
Small castings	1/16 in.
Variations from drawing dimensions per inch of diameter or length	0.001 in.
Cast Threads, Minimum Number, External	24 per inch
Internal	depends on conditions, often cast
Cast Holes; Minimum diameter	0.031 in.
Depending largely upon the depth and thickness of casting.	
Draft: Cores, 0.001 in. per inch of length or diameter.	
Side walls, 0.001 in. per inch of length.	

General Design. Sections of castings should be as uniform as possible. Sharp corners should be avoided and fillets added wherever permissible. Undercuts in castings should be avoided wherever possible.

General Remarks. Alloys of this type are corroded by any alkaline or aqueous solutions of any salts. Castings may be polished to a high luster, but soon tarnish when exposed to ordinary atmospheric conditions. Castings made from this alloy may be readily plated with nickel, copper, brass, silver or gold. When properly plated such castings will retain their luster as well as those made from brass or bronze.

[1] Doehler Die Casting Co.

Applications. Castings made from this alloy should not be used for parts that are subjected to severe stress or sudden shock in service. They are used extensively for parts of phonographs, calculating machines, drinking-cup, cigar, candy, stamp and gum vending machines, magneto housing, automobile-body trimmings, pencil-sharpening machines, time-recording devices, stamp-affixing machines, and for many other devices of a kindred nature.

GROUP B—TIN ALLOYS

Typical Alloys:

	Tin Per Cent	Copper Per Cent	Lead Per Cent	Antimony Per Cent
No. 1	90	4.5	0	5.5
No. 2	86	6	0	8
No. 3	84	7	0	9
No. 4	80	0	10	10
No. 5	61.5	3	25	10.5

Alloy No. 1 is a so-called "genuine babbitt" metal and was used very extensively during the war for main-shaft and connecting-rod bearings on all American-made aeroplanes and motor trucks. No. 2 is somewhat harder and is used extensively for bearings of internal-combustion engines. No. 3 is somewhat harder than alloy No. 2 and is the S. A. E. standard for high-grade internal-combustion-engine bearings. No. 4 is in general use for light bearings on stationary motors. No. 5 is a bearing metal for light duty and is used on a large number of moderate-priced automobiles for mainshaft and connecting-rod bearings.

In addition to the five compositions mentioned, hundreds of similar alloys may be made having various specific properties. A study of these alloys, however, would prolong this paper unduly, and in the opinion of the writer, is beyond its scope. The die-casting process, it may be said, is applicable to any of the alloys of this group and it may be left with the engineer to specify the alloy best suited to his requirements.

General Properties:

Maximum fusing point	450 deg. fahr.
Weight per cu in.	depends on lead content

Casting Limits:

Maximum weight for casting	10 lb.
Limit in wall thickness	1/32 in.
Variations from drawing dimension per inch of diameter or length	0.0005 in.
Cast Threads, minimum number:	
External	27 per inch
Internal	depends on conditions, often cast
Cast Holes: Minimum	0.031 in. diameter, depending on depth and thickness of casting
Draft: Cores, 0.0005 in. per inch of length and diameter.	
Side walls, 0.001 in. per inch of length.	

Applications. Tin alloys find their largest field of application in their use as bearings for internal-combustion engines. They are also used for parts of soda fountains, cream separators, milking machines, surgical apparatus, galvanometers parts, player pianos, etc., where a tensile strength of over 8000 lb. per sq. in. is not essential and where resistance to corrosion is of importance. They are not affected by water, weak acid or alkaline solutions, and when free from lead, are extensively used for food-container parts.

GROUP C—LEAD ALLOYS

Typical Alloys:

	Lead Per Cent	Tin Per Cent	Antimony Per Cent
No. 1	83	0	17
No. 2	90	0	10
No. 3	80	10	10
No. 4	80	5	15

Alloy No. 1 is generally known as C. T. (Coffin Trimming) metal, due to its extensive use in the manufacture of coffin trimmings. This alloy is also a good bearing metal for light duty and is used for thrust washers and camshaft bearings on light internal-combustion engines. No. 2 is somewhat softer and more ductile than No. 1. No. 3 is used extensively for light bearing duty, being somewhat tougher and stronger than Nos. 1 and 2. No. 4 is somewhat harder than No. 3 but less ductile. Many similar alloys may be compounded, all of which may be die-cast readily.

General Properties:
Weight per cu. in. ..... depends on lead content
Maximum fusing point ..... 600 deg. fahr.

Casting Limits:
Maximum weight for casting ..... 15 lb.
Minimum wall thickness ..... 1/32 in.
Variation from drawing dimensions per inch of diameter or length ..... 0.001 in.
Cast Threads, Minimum Number:
External ..... 24 per inch
Internal ..... depends on conditions, often cast
Cast Holes: Minimum diameter ..... 0.031 in. depending on depth and thickness of casting
Draft: Cores, 0.0005 in. per inch of length and diameter
Side walls, 0.001 in per inch.

Applications. Lead alloys may be used where a metal of non-corrosive properties is desired and where a tensile strength of not over 8000 lb. per sq. in. will suffice. They are used extensively for fire-extinguisher parts, low-pressure bearings, ornamental metal-ware, and many parts that come in contact with corrosive chemicals. They should not be used for parts that may come in contact with foods or that may be handled often in service, since the poisonous properties of lead and lead alloys are well known.

The main advantage of these alloys lies in their comparatively low cost, but their high specific gravity must be considered, some lead alloys having a specific gravity double that of the zinc alloys.

During the war lead alloys were used for all hand-grenade fuse parts and many millions of these parts were made. Lead-alloy die castings were also used for thermite grenades, offensive grenades, trench-mortar fuse plugs and many other parts where a non-corrosiveness was an essential requirement.

Group D—Aluminum Alloys

Typical Alloy:
Aluminum, 92 per cent; Copper, 8 per cent.

Properties:
Color ..... silver white
Weight per cu. in. ..... 0.115 lb.
Melting point ..... 1150 deg. fahr.
Tensile strength ..... 21,000 lb. per sq. in.
Elongation ..... 1.5 per cent
Hardness number (Brinell) 60.5

Casting Limits:
Maximum weight for castings ..... 5 lb.
Minimum wall thickness ..... 1/16 in.
Variation from drawing dimensions per inch of diameter or length ..... 0.0025 in.
Cast Threads, External: Minimum number ..... 20 per inch
Threads are cast oversize 0.01 in. to be chased to size. Internal threads rarely cast.
Cast Holes: Minimum diameter 0.093 in. and not deeper than 1 in. Larger cores may be cast much deeper; smaller holes may be spotted to facilitate drilling
Draft: Cores, 0.015 in. per inch of diameter or length. Side walls, 0.005 in.
Cores of less than ¼ in. diameter to have 0.005 in. draft per in of length and diameter.

The composition described above is well known in the arts as No. 12 alloy and is used very extensively for automobile and aeroplane parts. By varying the copper content harder or softer alloys may be obtained, all of which may be die-cast successfully.

Applications. Aluminum die castings find wide employment in the manufacture of parts of automobiles, such as spark and throttle control sets, magneto parts, battery ignition and lighting systems, speedometers, etc. They are also used for parts of vacuum sweepers, phonographs, milking machines, vending machines, etc.

Brass and Bronze Die Castings

Die castings made from various types of brasses and bronzes were put on the market as early as 1910, but have never been successful commercially. At the present time there is only one die-casting manufacturer producing brass die castings in any appreciable quantity.

It is a comparatively simple matter to produce a small quantity of sample brass die castings, but no material has yet been found for die-making purposes, which will withstand the continuous action of molten brass and at the same time retain its shape, surface and size. The die casting of brass and bronze must be considered as in the experimental stage at the present time, with little or no immediate prospect of the solution of the problem.

Developments Due to the War

The most important development in the art of die casting during the war was the perfection of the process of die casting aluminum and its alloys. A suitable steel was developed for making the dies for this process that would withstand the action of molten aluminum without cracking, a problem the solution of which was essential to the development of the industry.

The part that this development played in the winning of the war will be readily appreciated when it is stated that at the cessation of hostilities there were being produced about one million aluminum die castings daily in this country for parts of gas masks, machine guns, aeroplanes, motor trucks, motor ambulances, surgical instruments, canteens, field binoculars, and many other appliances of war.

Comparative Cost of Die Castings

The cost of die castings cannot be computed on the pound basis since it depends on the design of the piece, the number and position of the cores, the quantity to be produced and certain other factors. For comparative purposes it may be stated that at the present time tin-alloy castings are the highest in cost, being followed by those of aluminum alloy, zinc alloy and lead alloy in the order named.

In considering the use of die castings it is well to bear in mind that on a pound basis die castings are far more expensive than iron sand castings where the machining cost is not considered. As the zinc alloys, whose properties are similar to cast iron, cost from $200 to $275 per ton in ingot form, it is apparent that the substitution of a die casting for an iron casting can only be considered when the machining cost is sufficient to compensate for the difference in cost of the raw materials.

BRASS AND BRONZE CASTINGS

By CHRISTOPHER H. BIERBAUM,[1] BUFFALO, N. Y.

THE terms "brass" and "bronze" are not as definite in their meaning as might be desired. The term bronze was formerly applied to an alloy of copper and zinc. Usage, however, has changed and it is now generally applied to an alloy of copper and tin, while the term brass is used to denote an alloy of copper and zinc. This change of nomenclature has led to a great deal of confusion. Even today we speak of crank-pin, crosshead, or engine brasses when we have bronzes in mind; that is, a copper-tin alloy with comparatively little, if any, zinc in its composition. In general, it may now be said that without a modifying adjective brass is an alloy of copper containing a large amount of zinc; and bronze is an alloy of copper containing a relatively large amount of tin. In this country no general standard of terminology for these alloys has as yet been adopted; the British Institute of Metals has adopted one, but theirs does not seem entirely satisfactory for our purpose. For the present, in this discussion, these alloys will be designated according to the prevailing commercial usage in this country; and other alloys will, as far as possible, be designated in the order of their preponderant constituents. Thus, the copper-tin-lead alloy is one containing, by weight, more copper than tin, and more tin than lead.

It is very generally understood that in designing machine parts which are to be made of cast materials a larger factor of safety is necessary than that required for rolled or forged material, although the compositions may be very similar or even identical. This in itself is not sufficient. The fact that the strength in any given casting varies in its different parts must also be taken into consideration, since it is impossible to make a casting with varying sections of uniform strength.

[1] Vice-President, Lumen Bearing Co. Mem.Am.Soc.M.E.

PRECAUTIONS TO BE TAKEN IN SPECIFYING BRASS AND BRONZE CASTINGS

In general, the engineer should be cautioned against specifying alloys upon which he has only such knowledge as has been derived from laboratory tests alone, since it is impossible to determine, by ordinary experiment, all of the economic conditions which enter into the founding and tooling of a casting and the requirements of a subsequent satisfactory use of an alloy for any given service. To illustrate: Years ago the favorite Government composition known as gun metal (88 per cent copper, 10 tin and 2 zinc) was unreservedly specified for valves, steam connections and fittings. At the present time, however, no successful valve manufacturer would think of using this alloy for this purpose, although, from purely laboratory results this and similar high-tin alloys may appear to meet the requirements. The safe procedure is either to investigate and follow standard practice, or determine definitely why it should not be followed; or else to leave the composition and the guarantee of results to a responsible manufacturer and hold him accountable.

Aluminum should never be used in an alloy which is to be tight against leakage of either a gaseous or fluid substance. Aluminum has the peculiar property of forming a characteristic skin upon the surface of its alloys, due to its great affinity for oxygen. Appreciably less than one two-hundredth of one per cent of aluminum produces an appearance upon the surface which is very distinctly that of a brass or bronze casting. In fact, this surface film is often found in castings where the amount of aluminum present is so small that the chemist may be in doubt as to whether even a trace of it exists. In pouring a casting containing aluminum this surface film becomes entrained in the convecting currents as the molten metal fills the mold and often extends through the entire thickness of the wall of the metal and thus gives rise to porosity which causes leakage. For the foregoing reasons it is always desirable, when pouring, that the molds should fill with as little bubbling and splashing as possible. This applies to all alloys in general, but to those containing aluminum in particular. The "horn gate" or some form by means of which the molten metal enters at the lowest point in the mold is very desirable.

In the alloying of copper and tin a low-fusing crystal forms known as the tin-copper eutectoid. This crystal is hard and brittle and in general should not be present in bronzes used for machine parts; and more particularly so if these parts are subjected to temperatures approaching that of high-pressure steam. This crystal always forms in ordinary foundry practice when tin is present in amount equal to 9 per cent of the copper content. In slow cooling the amount of this crystal is increased and slow cooling also causes it to appear with a lower percentage of tin. High-tin bronzes should neither be used under high temperature nor where they are subjected to severe shock. Without doubt this eutectoid crystal constitutes the most valuable bearing crystal for bearing metals to be found in any of the bronzes.

Considerable experimental work has been done at different times and in different laboratories on the subject of heat treatment of foundry bronzes and brasses which are to be used without subsequent forging or tooling. These experiments have been applied particularly to the copper-aluminum alloys and to the copper-tin alloy known as gun metal. Nothing, however, has as yet developed to bring this process of heat treatment into general commercial importance.

Brass-foundry products do not compete directly with cast iron, cast steel or steel forgings in machine construction. They are specified by the designer only when certain properties are necessary, such as appearance, bearing value, chemical composition, and the like. These non-ferrous products never can compete directly in cost with the ferrous products for the reasons that copper is always higher-priced than iron and the price of tin is always subject to foreign speculation; while few of the minor constituents compare favorably in price with iron.

BRONZES

Manganese Bronze is the term generally applied to a composition which, properly speaking, is a brass instead of a bronze. It is an alloy of copper containing a high percentage of zinc, aluminum and iron, in which a small amount of manganese has been used. The beneficial effects in this alloy due to the deoxidizing and iron-carrying properties of the manganese are very striking. Beneficial results are obtained even though no more than a mere trace of manganese finally remains in the resulting product. In none of the brass-foundry products are the high merits of an alloy so much due to the results of skilful and intelligent foundry practice as in the case of this particular alloy. The composition is relatively cheap when the cost of its constituents is considered.

The cost of the final product, however, is much higher than its composition would indicate, due to the following requirements necessary for the production of satisfactory castings: The introduction of a small percentage of iron is necessary for proper results, and care and skill with proper equipment are indispensable for this operation; secondly, the amount of metal required for gates, heads and risers necessary for this alloy is unusually large, so much so that in the production of ordinary automobile castings only from 17 to 39 per cent of the entire metal melted finally appears in the form of finished castings; and lastly, the loss in melting is unusually large. For machine construction this alloy, of all brass-foundry products, is of first importance. In strength it successfully competes with steel castings and steel drop forgings although the price is from three to five times that of malleable castings. This, and its non-corroding properties make it a most desirable material in automobile and marine construction. As a foundry product it is a very desirable material as it has a very smooth surface. The labor for finishing it is in many cases so light compared with that required for finishing steel castings that it can often compete with steel castings. This is especially true in automobile construction. It has the necessary strength for brackets, standards and fixtures, so that it can replace both steel castings and forgings for these purposes. Manganese bronze has a field of usefulness in experimental work in that it can be produced with less delay than steel forgings, stampings or malleable castings, requiring as it does so little finishing. By varying the two principal constituents of manganese bronze the desired physical characteristics can be obtained. An increase of the percentage of copper increases its elongation, whereas an increase in zinc increases its ultimate tensile strength but decreases its elongation. When this material is made up with the necessary precautions as to purity and foundry methods, very excellent commercial results can be obtained. For example, a tensile strength of 90,000 lb. per sq. in. with 30 per cent elongation can be secured in a standard test coupon, whereas many producers consider 65,000 lb. tensile strength with 15 per cent elongation as fair.

Aluminum Bronze is an alloy of copper and aluminum containing from 4 to 11 per cent of aluminum and the remainder copper. In recent years, however, this alloy has been made up with an addition of from 1 to 6 per cent of iron. The introduction of iron produces twofold results: First, it causes the alloy to solidify with smaller crystals, that it, it produces a finer grain; and secondly, it adds a third hard crystal formed by the union of aluminum and iron which is much harder than the other two crystals. This is the only brass-foundry product which can compete commercially with manganese bronze. With care it can be so made up as to have a somewhat higher ultimate strength than manganese bronze, although it does not possess a higher yield point or elastic limit. The drawback to this alloy is the inherent difficulty of making solid castings. The tendency to have blowholes is very characteristic, and even extreme skill will overcome this difficulty only in a degree. Aluminum bronze may be used for bearing purposes, and recently, when containing iron, has had a limited use for motor-truck worm drives. The only advantage of this latter alloy over a copper-tin-bronze composition is its cheapness; for bearing purposes, however, it cannot compare with a copper-tin alloy.

Acid-Resisting Bronzes. These are some of the brass-foundry products which formerly were of more importance than they are today, owing to the fact that stoneware and specially modified cast iron are now largely replacing these uses. There are, how-

ever, some uses for bronzes to resist sulphuric and sulphurous acids in mine service, pulp mills, and other industries. For these purposes two alloys are most serviceable; a copper-tin-lead alloy containing substantially 86 per cent copper, 12 per cent tin and 2 per cent lead; and aluminum bronzes containing a small iron percentage.

Copper-Tin Alloys. First among these alloys highest in its tin content may be mentioned bell metal, a composition containing from 16 to 25 per cent of tin. As the name implies, it is used for the manufacture of bells, gongs, steam whistles and the like. It is a resonant metal. For industrial purposes the compositions used are those having the lower percentages of tin, say from 16 to 18 per cent. The higher percentages of tin, especially between 20 and 25 per cent, are used for bells in which high tone quality is required. The production of these bells requires considerable skill and constitutes a special industry. In general, however, it may be said that for all purposes the constituents for these alloys should be extremely pure and every precaution against oxidation should be taken during melting and pouring, since the quality of the product is altogether dependent upon the purity of the alloy.

The next alloy of this type to be considered is a bronze used in turntables and movable bridges. This composition is given in the tentative A.S.T.M. specification as "Class A, Bronze Bearing Metals for Turntables and Movable Bridges." It is also given as "Grade A" in the American Railway Engineering Association specification bulletin of July, 1918. It contains 20 per cent of tin, and phosphorus not to exceed 1 per cent. It is very hard, due both to its tin and its phosphorus contents. For best service conditions it should not be used except when placed between hardened steel plates. It is intended for pressures over 1500 lb. per sq. in. and slow-moving bearings.

A composition similar to the foregoing is one given as "Class B Bronze" under both of the immediately foregoing specifications and containing 17 per cent of tin with a permissible phosphorus content of 1 per cent. It does not seem wise to permit this amount of phosphorus in a bearing metal of this kind, however, if to be used as specified between "soft steel plates." Better service conditions can be obtained by the production of the necessary hardness through increase of tin content and reduction of phosphorus. An alloy containing 19 to 20 per cent tin and only a trace of phosphorus would give better service when used on soft steel. In a case of this kind where a copper-tin bronze is used between unhardened steel surfaces the amount of phosphorus present should be very limited owing to the exceeding hardness of the copper phosphide crystals.

The next alloy of importance as to its tin content is a bronze containing 11 per cent of tin and a maximum of 0.2 per cent of phosphorus. This alloy is the standard composition now in very general use for worm wheels in motor-truck drives and in the motor-car reduction worm gears. A feature of considerable importance in the making of this alloy seems to be that of producing the proper amount of chilling effect in the cooling of the castings. In some cases zinc has been added to an amount of 2¼ per cent; results show, however, that the addition of zinc is undesirable although it produces an additional hardness of the alloy as indicated by the Brinell and scleroscope tests. This additional hardness rather detracts from its bearing value, and, at the same time, makes it more difficult for tooling. It seems self-evident that the above alloy, as it now stands, could be improved by the addition of a small amount of lead,—not sufficient to produce undue weakening,—and that this would result in a threefold benefit: easier tooling, increased accuracy of tooled surfaces, and a higher bearing value.

Copper-Tin-Zinc Alloys. The most popular alloy of this class is the one known as ordnance bronze or gun metal. Its composition is 88 copper, 10 tin and 2 zinc. This alloy has come to be a very generally known composition in that it is a general-average bronze. However, with a more complete metallurgical knowledge of the relative values of different compositions, it becomes of less importance, in that it is specifically neither a bearing bronze of high merit nor a bronze especially adapted for machine parts when maximum economy of alloy is considered. The high tin content produces in this alloy a high percentage of the tin-copper eutectoid, with the resulting disadvantages when the alloy is used for other than bearing purposes. The use of ordnance bronze for the construction of machine parts is, for two reasons, a wasteful one: It contains an unnecessary amount of tin, a high-priced constituent, and more serviceable alloys can be produced by the use of a lower percentage of tin. For machine parts, steam connections and valves, a composition having, say, 90 per cent copper, 6½ tin, 2 zinc and 1½ lead is a superior alloy for the reasons that it can be produced as a more economic foundry product, its price is less, its physical properties are superior, and lastly, its machining qualities are superior. On the other hand, the zinc in ordnance bronze distinctly detracts from its bearing value.

Copper-Tin-Lead Alloys. These alloys are strictly bearing compositions containing not in excess of 82 per cent of copper and a tin maximum of 11 per cent with a lead maximum also of 11 per cent. This range of alloy corresponds to "Class C" of the A.S.T.M. tentative specifications for Bronze Bearing Metals for Turntable and Movable Railway Bridges. These alloys are usually deoxidized with phosphorus which has a tendency to suspend or diffuse the lead, since in all these alloys the lead is held in mechanical suspension without any chemical union. The most generally used of this series contains 80 per cent copper, 10 tin and 10 lead.

To enumerate all of the copper-tin-lead alloys given by various authorities as bearing bronzes would constitute an almost infinite series. The whole matter, however, can be summed up in a few words: Lead is a desirable constituent in a bearing alloy but has the drawback of weakening the bronzes, therefore, for light service, or under conditions where a supporting oil film cannot always be maintained, as in car or truck bearings, the compositions containing the higher proportions of lead should be used. Where the punishment is severe the alloys should have a lower percentage of lead. As a rule it is economy to use as much lead as possible, since lead is a cheaper metal and it also adds materially to the bearing value of the alloy.

Copper-Lead-Tin-Zinc Alloys are those containing from 3 to 12 per cent of lead, from 4 to 6 per cent of tin and from 1 to 10 per cent of zinc. This series of compositions includes several used for bearing purposes, especially those having the high lead limits. The addition of zinc in this alloy is for the purpose of reducing the cost; it does not add to the value of the alloy except in its physical strength and it detracts from its bearing value. The series includes the popular red-brass composition; 85 per cent copper, 5 tin and 5 zinc; and also a cheaper composition containing 77 per cent copper, 10 lead, 3 tin and 10 zinc used for low-pressure valves and plumbers' supplies.

GRAY-IRON CASTINGS

By RICHARD MOLDENKE,[1] WATCHUNG, N. J.

IN working out problems in machine design the mechanical engineer is constantly confronted with requirements for those parts he wishes to make of cast iron, which makes it necessary for him to be fully informed in regard to the latest developments in the foundry industry. Where to use a casting and what metal or alloy to make it from should be pretty well known by now, but what class of cast iron to use and what kind of a foundry to get it from may be matters open to doubt in these days of rapid changes. Therefore, even though he depends upon the foundryman to deliver him the kind of casting he needs, the engineer should have some knowledge of the underlying causes for the peculiar properties exhibited by cast iron when put into the form of castings.

The Carbon Situation in Cast Iron

To understand the nature of the complex material known as cast iron it is necessary to go behind the returns of an "ultimate analysis," as it were, in order to get the "rational" analysis, or the grouping up of the several elemental constituents. Here it

[1] Consulting Metallurgist. Mem.Am.Soc.M.E.

will be seen that the total carbon is present in two forms, part of it being a mechanically mixed crystalline graphite and the remainder being chemically combined. The amount, distribution and physical condition of the graphite thrown out of solution at the moment of set are the more particular items of importance to the engineer in connection with the strength and machinability of the casting. While the total carbon of the metal is the same throughout the mass, the division into mechanically mixed graphite and combined carbon will be such that the highest proportion of the former will be found in the center of the section, together with the least of the latter form, and vice versa. Since the presence of combined carbon in increasing proportion means corresponding increase in hardness, the metal at the surface of a casting will be harder than in the center. Further, the oxide of iron formed through contact of molten iron with a damp mold surface and the fluxes in the molding sand, if not properly covered with adhering graphite, on interacting form an enamel which is very hard on the cutting tool, and hence this should be made to dig under the skin of the casting and lift the surface metal away as it cuts along under lubrication of the graphite present and not be allowed to glide over the skin.

With the foregoing explanation of the carbon situation in cast iron, and remembering that graphite is in mechanical admixture only, and consequently is an element of weakness by cutting up the continuity of the iron mass, it will be understood that fundamentally cast iron is a steel of given combined carbon content, with the other elements present in much higher percentages than one would expect in any steel. For instance, if the percentage analysis of the chips taken from the first eighth inch below the surface of a flat plate gave silicon 2.00, manganese 0.70, phosphorus 0.45 and sulphur 0.12; with graphite 3.20 and combined carbon 0.30; then that part of the plate was for practical purposes a 30 carbon steel containing much graphite, double the usual sulphur and ten times as much phosphorus as a steel ought ordinarily to contain. The fact that the proportions of the two forms of carbon vary from surface to center conclusively shows that while the total carbon of a cast iron analysis may be perfectly reliable, the items "graphite" and "combined carbon" in such an analysis are worthless unless the actual point from which the sample has been taken is indicated.

Silicon as the chief determining factor of the condition of the carbon present may run from as low as 0.35 per cent in deeply chilled castings up to 3.25 per cent in the very lightest of hardware and novelty work. The absence of silicon allows the carbon to remain in chemical combination with the iron. As the percentage of silicon increases the iron loses its power to hold the carbon in combination and it is thrown out as graphite at the moment of set. The higher the silicon the greater the graphite percentage. A factor affecting the silicon content to be employed is the rate of cooling of the metal when a mold is filled with molten iron. The thinner the section the greater the power of the iron to hold the carbon in chemical combination in spite of the silicon present. Hence high silicon is necessary to prevent thin sections from turning out hard, and since the foundryman must deliver his casting in condition to machine properly, he naturally regulates the silicon of his mixture to care for the thinnest section. If he were to aim for strong iron with a reasonable machinability for the heavier sections of the casting to be made, making his mixtures accordingly with high-steel-scrap percentages and comparatively low silicon, the thin ribs and brackets of the casting would come out hard and brittle, if not actually white in fracture, and the greater contraction of these in cooling from the molten state would cause bad warping and internal strains. The mechanical engineer should therefore study the metallurgical side of the foundry requirements so that he may design his work with the least abrupt changes in section, avoid sharp corners and distribute his metal to the best advantage—in other words, give the casting a chance.

The total-carbon percentage has come to be a most important factor in the iron-castings industry. Of recent years the comparatively low-total-carbon iron made in the air furnace, and called "gun iron" from its use previous to the days of the steel cannon, has been paralleled by cupola metal in which great quantities of steel scrap are added to the mixture. Even in the air furance, the former long periods of refining to reduce the total carbon are shortened by adding all the way up to 30 per cent of steel scrap to the mixture of pig irons and home scrap. The product gets the erroneous name of "semi-steel" from those who are not informed on the properties of this grade of cast iron—for it is only a high-grade cast iron, with none of the properties of steel. Its importance to the engineer lies in the fact that the reduction in total carbon through steel additions can be carried to a point where the ultimate strength is nearly doubled and where the chips taken from such a casting curl up almost as well as those from hard steel, for which reasons it serves very well where it is not essential that steel be used. The foundryman, however, has a problem before him in running these high steel-scrap heats. Only the best of cupola and mold-gating practice will yield castings free from blowholes, cracks and serious internal shrinkages. The silicon percentage must be watched particularly, so that separation of graphite and combined carbon may leave the latter low enough for proper machinability. The effect of low total carbon (it may be brought down to 2.25 per cent, or just above the line of division into steel), if the combined carbon is kept normal, is to give an otherwise lower graphite percentage. Necessarily this graphite is finer in crystallization, and there being less of it than normal, the planes of separation in the solid metal are smaller and fewer, hence the greater strength. Moreover, there is much less phosphorus present as the result of the low phosphorus of the steel added.

Manganese in the castings should not be allowed to run below 0.50 per cent and not over 1.00 per cent for normal machinable work. Phosphorus should be as low as possible, considering the pig irons that must be used, and for important and thick work had better run below 0.40 per cent. Very thin castings, such as art and architectural details in structures, which really correspond to the "stove plate" of the foundryman, require very nearly 1.00 per cent of phosphorus to come out in perfect detail. Table 1 gives recommended compositions of castings for many purposes. It is not wise for the engineer to specify the chemical composition of the castings he requires, but if strength is important it should be specified according to the standards of the American Society for Testing Materials.

Specialization in Iron Founding

The foundry industry is pretty well divided up into specialized lines of work. If the engineer needs chilled castings he turns to the makers of chilled rolls. Many foundries, however, other than roll makers produce crusher castings, balls for grinding, shoes and dies for stamp mills. Another important branch of foundry work is the making of cylinders. For the highest grade, foundries having air furnaces should be selected, particularly if they make a specialty of cylinders, piston rings and the like; and they will be found among the great foundry and machine works of the country building heavy machinery and engines, particularly of the marine type. Castings to withstand high pressures, such as those of air, steam and ammonia, are made by foundries specializing in air compressors, pumps, refrigeration machinery, and the general valve and fitting trade. For light parts to serve for ornamental purposes there are many stove shops to which recourse may be had. In general, however, where reciprocating parts or sections of intricate character and for severe service strains are required, it is safer to go to the large concerns making well and favorably known lines of product. The foundries connected with such establishments have the proper facilities and the trained men to undertake the work, and will be in position to advise improvements in design to give the metal a better chance for the purpose intended. Foundries of the class just mentioned usually have need of several mixtures of iron to supply the parts required for the line of machinery turned out. Hence, they usually run a few charges of fairly low silicon, high steel scrap-metal for such castings as air-compressor cylinders, rolling mill parts, and other work of high strength and density. The next charges may then care for ordinary machinery castings, and finally

a few extra soft or high-silicon charges may care for pulleys and the very light-section product. Sometimes the process is reversed, all light, soft work being run first and the harder classes at the end of the heat.

Recent Tendencies in Gray-Iron Foundry Practice

The passing of the war has given us time to realize more fully the train of evils that have been its legacy to the foundry. While there was a tremendous expansion of other industries due to war demands, the foundries simply pushed production to the utmost consistent with ability to get raw materials and men. Impossible prices for pig iron resulted in the use of so high a proportion of scrap in the mixtures that when the castings made during this period of stress eventually land into the scrap piles of the country—probably within the next twenty years—a serious problem of very high sulphur and oxidized iron will confront the foundryman. Instances of 90 per cent scrap in the mixture were common and castings with over 0.20 per cent sulphur equally so.

The problem will have to be faced, and there are two possible solutions. The method heretofore employed in such a case is the increased use of pig iron in the mixtures. Before the war the common practice was to use not over 40 per cent scrap with 60 per cent pig. Now it is reversed. Consequently, instead of having the sulphur run about 0.08 per cent maximum in important work, it is more nearly 0.12 per cent. Ordinary work today touches 0.18 per cent without much comment. It is true that even a higher sulphur content will not militate against machinability provided the melting practice is of the very best, but the castings are more subject to danger from shock and casting strains.

The other method for correcting the high-sulphur tendency in daily work at present and for that to come is a desulphurization process in which the regular cupola method is employed, the molten metal being transferred into an electric furnace having a basic lining. In this way the heavy current variations are avoided, and by taking advantage of the comparatively cheap cupola-melting cost, that of the electric furnace for refining only is very materially reduced. It is a question whether more than a quarter of a cent is thus added to the cupola-melting cost per pound of metal "duplexed," where current is cheap.

Molten cupola metal, with possibly 0.12 per cent sulphur, may thus be brought down to about 0.05 per cent, and even lower. Moreover, the metal is highly superheated—cupola metal itself is intensely hot as compared with furnace iron—and thoroughly deoxidized. The castings made are therefore much better and sounder than the ordinary run, equaling charcoal-iron castings made in the air furnace. The first cost of the installation is high, but it soon pays for itself in the quality of work turned out. While developed during the war period, it is none the less a logical sequence in the world advance of the art of making iron castings and should be welcomed as a satisfactory way out of a very bad situation ahead.

In conclusion, the mechanical engineer is urged to turn his attention more specifically to foundry operation. The technical staffs of all the foundries of continental Europe, from manager down to assistants in the several production and testing departments, are all graduate engineers. The consequence is that castings are made strictly for the purpose intended, and not merely to get by the machine shop safely, as is unfortunately so often the case here. Close coöperation between men trained in the science with those trained in the art of making castings can only result in good.

TABLE 1 RECOMMENDED ANALYSES FOR VARIOUS CLASSES OF CASTINGS

Castings	Light					Medium					Heavy				
	Si	Mn	S	P	T.C.	Si	Mn	S	P	T.C.	Si	Mn	S	P	T.C.
Acid-resisting	2.00	0.75	0.05*	0.20*	3.25*	1.50	1.25	0.05*	0.20*	3.25*	1.00	1.25	0.05*	0.20*	3.25*
Agricultural	2.50	0.60	0.06	0.75	3.75	2.25	0.70	0.08	0.70	3.50	2.00	0.80	0.10	0.60	3.25
Air Cylinders	1.90	0.70	0.08	0.50	3.40	1.50	0.80	0.08	0.40	3.25	1.00	0.90	0.10	0.30	3.00
Annealing Boxes						0.65	0.20	0.08	0.20	3.50					
Automobile Cylinders	2.25	0.65	0.08*	0.40*	3.25*	2.00	0.75	0.08*	0.30*	3.25*					
Balls for Grinding						0.75	0.50†	0.15*	0.40*	3.75†	0.50	0.50†	0.15*	0.40*	3.75†
Bedplates	2.00	0.70	0.08	0.60	3.75	1.75	0.75	0.10	0.50	3.50	1.50	0.80	0.12	0.30	3.25
Boiler Castings						2.00	0.80	0.06*	0.20*	3.50*					
Car Wheels											0.65	0.50	0.08	0.35	3.50
Chilled Castings												1.00	0.06*	0.20*	3.50*
Chills						1.00	0.50	0.05	0.20	3.00					
Crusher Jaws						1.00	1.00	0.04	0.20	3.50	0.80	1.25	0.06	0.20	3.25
Dies for Hammers						1.50	0.60	0.05	0.20	3.00	1.25	0.80	0.06	0.20	2.75
Dynamo Castings	2.70	0.50	0.05	0.75	3.75						2.15	0.50	0.06	0.50	3.25
Electrical Work	3.00	0.50	0.05	0.60	3.75	2.75	0.50	0.05	0.50	3.50					
Engine Frames						2.00	0.60	0.08	0.50	3.50	1.75	1.00	0.10	0.40	3.00
Fire Pots, Grates	2.25	0.60	0.05	0.20	3.50	2.00	0.80	0.06	0.20	3.25					
Fly Wheels	2.00	0.50	0.05	0.50	3.50	1.50	0.60	0.06	0.40	3.25	1.25	0.70	0.08	0.30	3.25
Friction Clutches	2.40	0.60	0.10	0.70	3.75	2.00	0.70	0.12	0.50	3.50					
Furnace Castings	2.30	0.60	0.05	0.60	3.75	2.15	0.80	0.06	0.50	3.50					
Gas-Engine Cylinders	2.00	0.70	0.08	0.40	3.25	1.50	0.80	0.09	0.30	3.00	1.25	0.90	0.10	0.20	2.85
Gears	2.25	0.60	0.08	0.70	3.75	2.00	0.80	0.09	0.60	3.50	1.50	1.00	0.10	0.50	3.25
Glass Molds, Pipe Balls						2.50	0.60	0.04	0.20	3.25					
Grate Bars						2.00	0.60	0.05	0.20	3.50					
Gun Iron						1.50	0.50	0.05	0.30	3.25	1.00	0.60	0.05	0.30	3.00
Hardware	2.50	0.70	0.08	0.80	3.75										
Heat-resistant Iron						2.00	0.80	0.06	0.20	3.25	1.50	1.00	0.06	0.20	3.00
Hydraulic Cylinders						1.50	0.80	0.05	0.40	3.25	1.00	1.00	0.08	0.20	2.85
Ingot Molds											1.25	0.80	0.06	0.20	3.75
Machinery Castings	2.50	0.60	0.08	0.70	3.75	2.00	0.80	0.09	0.60	3.50	1.50	1.00	0.10	0.50	3.25
Mine Wheels						0.90	1.00	0.10	0.20	3.00					
Ornamental Castings	2.75	0.60	0.06	0.90	3.75	2.25	0.70	0.08	0.80	3.50					
Pipe (Water)	2.25	0.60	0.06	0.80	3.75	2.00	0.80	0.08	0.70	3.50	1.50	1.00	0.10	0.60	3.50
Piston Rings	2.00	0.70	0.05	0.60	3.50	1.75	0.80	0.06	0.50	3.25					
Pulleys	2.40	0.50	0.05	0.70	3.75	2.15	0.60	0.07	0.60	3.50	1.90	0.70	0.09	0.50	3.25
Radiators	2.25	0.70	0.06	0.80	3.50										
Rolls (Chilled)							0.80	0.06	0.40	3.25		1.00	0.08	0.30	3.00
Soft Castings	2.60	0.50	0.06	0.60	3.75	2.40	0.60	0.08	0.50	3.50					
Soil Pipe	2.25	0.60	0.08	0.80	3.75	2.00	0.80	0.10	0.60	3.50					
Steam Cylinders	2.00	0.60	0.08	0.50	3.50	1.60	0.80	0.09	0.40	3.50	1.25	1.00	0.10	0.30	3.50
Stove Plate	2.50	0.50	0.06	1.00	3.75	2.25	0.60	0.08	0.80	3.50					
Valves	2.25	0.40	0.07	0.50	3.25	1.75	0.80	0.08	0.40	3.00	1.25	1.00	0.09	0.30	2.85
White Iron Castings						0.75*	0.20†	0.25*	0.75*	2.50†					

*Below. †Above.

DISCUSSION AT CASTINGS SESSION

Gray-Iron Castings

H. Wade Hibbard,[1] who was the first to discuss the paper on Gray-Iron Castings, called attention to the author's statement that "cast iron is ideal for frames for machinery of all kinds, and as it can be locally chilled it gives splendid wearing surfaces," and stated that it had always been his impression that a special grade of cast iron was needed if a chilled surface was desired, and that the grade of cast iron used for frames for machinery was not the grade commonly employed. To this Doctor Moldenke

[1] Prof. Mech. Eng., Univ. of Mo., Mem. Am.Soc.M.E.

replied that "chilled" may refer to one of two things. It may refer to an iron that has been turned perfectly white or an iron which is merely cooled sufficiently rapid to become coarse-grained.

John McGeorge[2] referred to the author's statement regarding the transfer of the melted iron to the electric furnace having a basic lining and asked if the use of such a lining did not eliminate the phosphorus. Doctor Moldenke stated that the phosphorus was not eliminated, and that the carbon must first be removed, also that the sulphur must be eliminated.

Mr. T. A. Bovie inquired as to the strength of the iron and Doctor Moldenke replied that it depends upon the proportion of graphite and that of course, in general, as the total carbon content is decreased the strength is increased.

Malleable Castings

Captain Hughes, who opened the discussion on the paper on Malleable Castings, called attention to the author's statement that the Ordnance Department was unfamiliar with the physical characteristics of malleable iron. He stated that the Ordnance Department was planning at the present time to make drop bombs out of malleable iron but has been unable to obtain satisfactory castings, especially in the larger sizes, and that furthermore the Department has had great difficulty in inducing the malleable-iron castings companies to undertake the necessary research work. He requested information as to where the Department might possibly secure satisfactory castings.

Doctor Moldenke gave as his reason for unsatisfactory castings, the fact that a white-iron casting has a contraction from the molten to the solid of over 12 per cent, and unless it is possible to take care of that contraction in the feeding of the metal, the outside of the casting will be sound but the inside porous. He also spoke of Professor Touceda's work in assisting the smaller foundries to manufacture a uniform product.

Professor Hibbard stated that thick sections in malleable castings have been feared by the designer and objected to by the manufacturer and he was therefore interested in the author's statement that "castings have been produced commercially as long as 5 ft. with sections at some parts as thick as 3 in." "With certain of our malleable-iron foundries," he said, "the ability to produce malleable-iron sections as thick as 3 in. or more has been known for several decades, but since malleable iron before it is annealed is essentially white and very brittle, by putting a chilling piece into the sand mold where the section is thick, that chilling piece thus renders it more capable of receiving the annealing process." Professor Hibbard said he wondered if our foundries are acquainted with this method of causing a thick piece to lend itself readily to the annealing process. Doctor Moldenke replied to Professor Hibbard's inquiry and stated that to his knowledge this particular method was commonly known. Doctor Moldenke also stated that from his experience he had found that malleable castings could withstand shocks better than steel castings. "There is nothing better," he said, "than malleable under shock."

Replying to an inquiry as to whether or not any work had been done toward the casting of malleable iron in permanent molds, Doctor Moldenke said that in making railroad tie plates in the permanent or iron molds he invariably found that the material so made was weaker than that made in a sand mold. He related his experiences in the production of the tie plates and called attention to the difficulties encountered, particularly those arising from the rapidity with which the metal chilled in the iron mold. He stated that in his opinion permanent molds would never amount to very much. "We ought to aim in a different direction," he said, "and make molds of a substance that will not be injured by one, two, three, four or even ten molds."

Lieut. E. R. Jackson[3] requested information dealing with the use of malleable iron in connection with parts for tractors and motor trucks. "Out of twenty of the standardized trucks that we took across the country," he said, "there wasn't a single valve tap that completed the trip. They all had to be replaced." He referred to Professor Touceda's statement that malleable iron can replace such parts, but said that to date they have not been satisfactory in the Army. Doctor Moldenke replied to Lieut. Jackson's inquiry and stated that the difficulty was probably due to the fact that when a malleable casting is skinned a large portion of the carbon content is removed. "There is a difference," he said, "between the malleable casting of America and the malleable casting of Europe." In Europe it is the practice to almost completely remove the carbon and as a result they obtain practically a steel, which, of course, wears very well. Over here, however, our castings do not have the carbon removed and consequently do not wear so well.

Steel Castings

Professor Hibbard was the first to discuss the paper on Steel Castings. He called attention to the author's statement that "when the service demands all the strength, toughness and resistance to wear and fatigue that are obtainable in a cast metal, a steel casting should be specified." He stated that perhaps he had an undue prejudice against wearing or suitability of cast steel on a rubbing surface and that in his own practice he did not employ steel castings with finished surfaces for rubbing surfaces.

Lieut. Jackson endorsed Mr. Hibbard's remarks, stating, however, that the Ordnance Department has found forged steel parts quite satisfactory for such work.

Mr. McGeorge related an experience in the production of large castings which did not shrink although a very considerable shrinkage was expected. The cores were very hard and they did not crush. "The following castings were annealed," he said, "in a large furnace which we built for that purpose. We then obtained the proper shrinkage."

Doctor Moldenke said that while he was not very well posted on steel castings, he had had similar experience with cast iron. "If the core is too hard," he said, "either the metal must give or it cracks. That is one of the reasons why in our foundry practice, when we make a pattern, we first make a casting and break it and measure it, for we may have to change that pattern."

Professor Hibbard also commented on this phase of the work and called attention to the methods employed by the Commonwealth Steel Company.

Captain Hughes stated that at the present time a very interesting case of steel castings failing to shrink the anticipated amount is to be found in the making of recoil bands for 16-in. guns. "We used to make them solid," said Captain Hughes, "and then in order to get greater weight, we cored them out and filled them with lead. We made some castings which weighed about 25 tons, and were about 129 in. long and 77 in. wide. On the 129-in. dimension they were about 1¼ in. long, throwing off all holes, ribs and other parts of the casting, so that it is necessary to make new castings, which is due to this same phenomenon of being unable to shrink due to hard cores. We annealed these castings afterward and realized the physical properties desired which are those of the U. S. Cast Steel, No. 3, which, as you know, are very high."

[Editor's Note: The time devoted to the discussion of the papers by Messrs. Moldenke, Touceda, and Hall consumed practically the entire time set aside for the Foundry Session, and those present at that session accordingly decided that the discussion of papers by Messrs. Pack, Jeffries, and Bierbaum should be in written form and included in the general account of the meeting. To date, however, but one discussion has been received. This is given below.]

Brass and Bronze Castings

Robert J. Anderson[4] (written). The paper by Mr. Bierbaum mentions the fact that in the case of manganese bronze sprue returns are exceptionally large—so much so that in the manufacture of ordinary automotive castings only about 17 to 39 per cent of the entire metal melted finally appears in the form of finished castings. In the other papers comprising the

(Continued on page 486.)

[2] Special Engineer, Ohio Body and Blower Co., Cleveland, Ohio. Mem. Am.Soc.M.E.
[3] Tank, Tractor and Trailer Div., Ordnance Dept., Washington, D. C.
[4] Bureau of Mines, Experiment Station, Pittsburgh, Pa.

McCook Field and American Aeronautics

Inception of McCook Field and Nature of the Work Carried on—The Problem of the Variable-Pitch Propeller—Development of Measuring Instruments—Research Work in Altitude Flying—Present and Future Potentialities of the Field

By LEON CAMMEN,[1] NEW YORK, N. Y.

A MODERN aeroplane is far more than a few sticks of wood and canvas thrown together with an engine and propeller stuck in. In many respects the design of an aeroplane is a real course in post-graduate engineering, even for those who have done extensive work in other lines. The aeroplane is the lightest craft for the amount of power that it carries, moves at greater speed than any other passenger-carrying vehicle, and is subject to a greater variety of stresses and influences than any other structure know to man. Moreover, these stresses and influences, the character of which is as yet little known, are most difficult to determine.

Classical economics used to say that all production involves three basic elements: land, labor and capital. In aeroplane construction more perhaps than anywhere else the fourth element of production plays a tremendously important part, and that is—knowledge.

Many delays in the execution of the American aeroplane program at the beginning of the war were due to the fact that we, in this country, did not have the accumulation of technical data, either theoretical or experimental, that was necessary to carry out the vast program undertaken, and that many of these data could not be secured even from abroad, where, notwithstanding all war regulations, they were a jealously guarded secret of commercial companies.

It takes a vast amount of painstaking work in experimenting, measuring, calculating and devising to secure data useful in aeroplane construction. Moreover most investigations bring in results in the form of tables, equations of stresses, or little matters of design which cannot be patented and made the exclusive property of some particular individual or company. Because of this, commercial aeronautic companies, such as there are, either do not undertake work of this character at all, or, if they do, guard the results as their trade secrets.

It is obvious, however, that if aeronautics is to be developed in this country there must be some place where investigations into matters pertaining to this new art can be carried on without any regard to immediate commercial returns. In other words, we have to have what practically amounts to a national laboratory for aeronautical research. In this direction a certain amount of work is being carried out in various institutions, but the place where such work is carried out probably on the largest scale is at McCook Field, Dayton, Ohio.

The Inception of McCook Field

The field happened to be located at that particular spot more or less accidentally. Since the days of Wilbur and Orville Wright, Dayton has, to a certain extent, been the aeronautical Detroit of the United States, and about the time of our entry into the war several companies located in that particular city were engaged in aeronautical work or in work having an important bearing on the art of flying. The War Department did its best to cooperate with them, and the original McCook Field was the result.

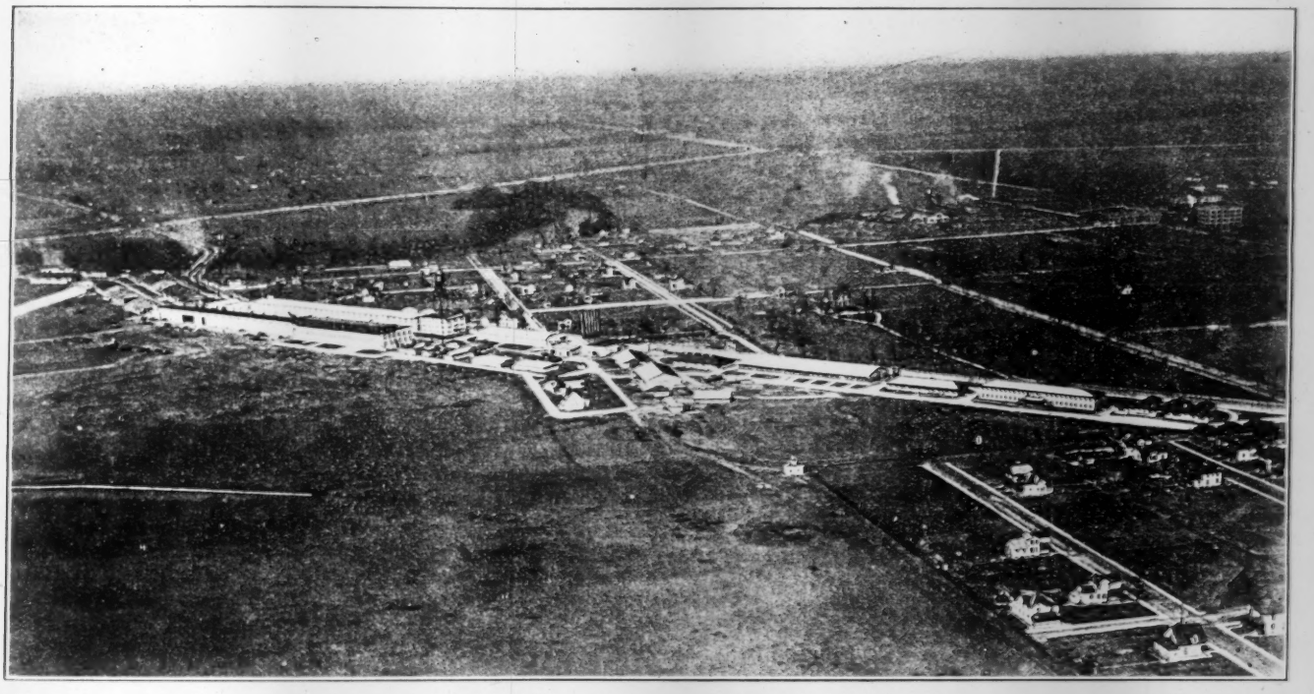


Fig. 1 Aerial View of McCook Field

It was quite a modest endeavor at first; but with our entry into the world war and the great appropriations granted by Congress for aeronautics, McCook Field rapidly assumed its present great proportions and, in fact, became the center of the main engineering activities of the Air Service of the Army.

The aerial view of the Field, Fig. 1, gives an idea of the scale on which this enterprise was carried out under the stress of war conditions when so much depended on the Air Service arm of our fighting forces.

The chief work on the development of the Liberty engine from its beginning to the present stage was carried out at McCook Field and many other investigations of great importance have passed through various stages of development in the same great organization.

[1] Associate Editor, Mechanical Engineering.

NATURE OF THE WORK CARRIED OUT AT MCCOOK FIELD

The work carried out at McCook Field is of an extremely varied nature and covers a wide variety of subjects, from trial flights in the course of which new equipment is being tested to the development of curves of performance of various apparatus, instruments of measurement, new devices and new laws in branches of engineering bearing on man flight.

During the war all that was done at the Field was naturally covered with the deepest veil of military secrecy, and even now research is carried on along lines and on subjects which are not yet ready for publication. A tremendous amount of work has been done, however, which can now be revealed. It may be stated, in this connection, that as far as possible the authorities at McCook Field never tried to make more of a mystery of their work than was absolutely called for either by the exigencies of war or the necessity for reticence about work yet in progress.

The Bulletin of the Airplane Engineering Department, U. S. A., and the Technical Orders of the Engineering Division, Air Service, Dayton, Ohio, available now to every American engineer who can show a bona-fide desire to use them for the good of the country, represent a very valuable source of information on research in the aeronautical field.

It was at the McCook Field, in coöperation with the Forest Research Laboratory, that the whole subject of veneers, plywood, and glue in aeroplane construction received the development which, in this connection, gave the United States the foremost position that it now occupies in the world. There were several other problems that were carried to completion at the Field. One of the first that may be mentioned is that of supercharging. Since the early days of the war it was noticed that engines, as they then were, lost a large proportion of their power at high altitudes. A partial solution was offered by the supercharger as built by Dr. A. Rateau, Hon. Mem. Am. Soc. M. E., in France, but further work was necessary before the apparatus could be made practical. The theoretical part of this work was carried out in the Altitude Laboratory of the Bureau of Standards, but it remained for the engineers of McCook Field to do the practical work—in coöperation with Mr. E. H. Sherbondy, of the De Laval Company, and especially Dr. Sanford A. Moss, Mem. Am. Soc. M. E., of the General Electric Company. The Moss supercharger was the one which was finally brought to the practical stage and important flights were made with it from McCook Field. The exact value of the supercharger on aeroplanes may not yet be clear, but there is scarcely any doubt as to its representing an important advance in the engineering of high-altitude flight. Another development of importance, the magnitude of which it is scarcely possible to realize today, is represented by the so-called variable-pitch propeller.

THE PROBLEM OF THE VARIABLE-PITCH PROPELLER

The efficiency of an aeroplane propeller depends on so many variables that it is practically impossible to design a propeller that will be equally efficient under all conditions. The propellers used today represent nothing but compromises designed to give the best efficiency under the average conditions under which the aeroplane is supposed to fly. This, however, deprives the aeroplane of a good deal of its flexibility and, for example, makes one designed to fly at moderate altitudes highly efficient at high altitudes, and vice versa. If we could make a propeller with a variable pitch and vary the pitch from the seat, it is obvious that we would have a means for adapting the propeller to the varying conditions of flight, and would give the aeroplane somewhat the same flexibility that the change gear gives to the automobile of today. The problem, though comparatively simple theoretically, proved to be a very puzzling one when it came to practical developments. It must be remembered in this connection that the variable-pitch propeller gear must be of light weight and yet have a high factor of reliability, and that the latter is made particularly difficult because of the fact that the amount of power transmitted through the gear is quite large—for example, with the Liberty motor, 400 hp. or more as compared with some 60 to 80 hp. that the change gear of an ordinary large automobile has to carry. A still further problem lay in the fact that a wooden propeller had to be made in two sections engaged with the variable-pitch gear and that means had to be found to hold the wooden parts in such a manner as to withstand the tremendous stresses induced by the centrifugal forces acting on the propeller and otherwise.

It would not be an exaggeration in any way to say that the development of a variable-pitch propeller installation represents as difficult a job in mechanical design as any that had to be tackled in the development of modern aeroplanes and its practical solution may be viewed with pride by the American engineering fraternity. This all the more so, as it may be expected that ultimately the solution of the variable-pitch propeller problem may lead not only to the improvement in the overall efficiency and flexibility of operation of the aeroplane but also to the solution of one of the most vital problems in aeronautics of today—the problem of insuring safety in landing.

To maintain itself in the air an aeroplane has to fly at a certain minimum speed. If that speed goes below the necessary minimum limit, the aeroplane will fall to the ground like a plummet, and this is what makes landing so difficult and dangerous. A high speed, varying from 30 miles for large and slow-going planes to some 60 miles or even more for the small, extremely fast machines, must be maintained up to the very instant the wheels touch the ground, and it is obvious that unless some way is found for braking an aeroplane, it will continue to move for quite a considerable time at the same speed after reaching the ground. An aeroplane, however, is not designed to run at very high speeds on the ground unless it is very smooth and even, and running on rough ground is apt to cause trouble either by breaking the landing gear or upsetting the plane. As a matter of fact, the extremely high-speed scout planes can land safely only on specially prepared landing fields.

The situation is about the same as if automobiles without brakes were permitted to travel at, say, 50 m.p.h., and it is easy to see how dangerous a pursuit motoring would have been under these conditions. There has been no lack of effort to provide braking for aeroplanes, but, unfortunately, practically all attempts in this direction have failed for one reason or another. However, there is what appears to be an entirely practical way of handling this problem and that is by using the aeroplane propeller itself as a brake, which means reversing the propeller at or immediately after the instant of landing on the ground. This requires that means for reversing the propeller and controlling its operation in the reverse condition should be available, and that is what the McCook Field work on variable-pitch propellers promises to give us.

It may be said that for work of this and similar character on propellers there are available at the Field unusually good facilities, and actual-size propellers can be tested in various ways with instruments necessary to determine the main features of propeller performance.

DEVELOPMENT OF MEASURING INSTRUMENTS AT MCCOOK FIELD

Another field in which a large amount of highly interesting work is carried on is that of instruments. In the early days scarcely any instruments were used in power-plant engineering work. Coal was weighed after a fashion and in some plants pressure gages were employed. The thermometer was also used, though grudgingly, and in a few laboratories rather crude dynamometer facilities were available on a limited scale.

It was the introduction of electric power generation and transmission which really laid the foundation for the modern view as to the importance of measuring instruments. The transmission and application of electric power was not feasible without instruments, such as ammeters, voltmeters and wattmeters, and when it came to alternating currents, frequency meters, etc. In this way the amount of power delivered to the generators was measured and known and this induced a feeling of curiosity as to what was happening at the steam end, which led to the more extensive use of the indicator first and to the development of

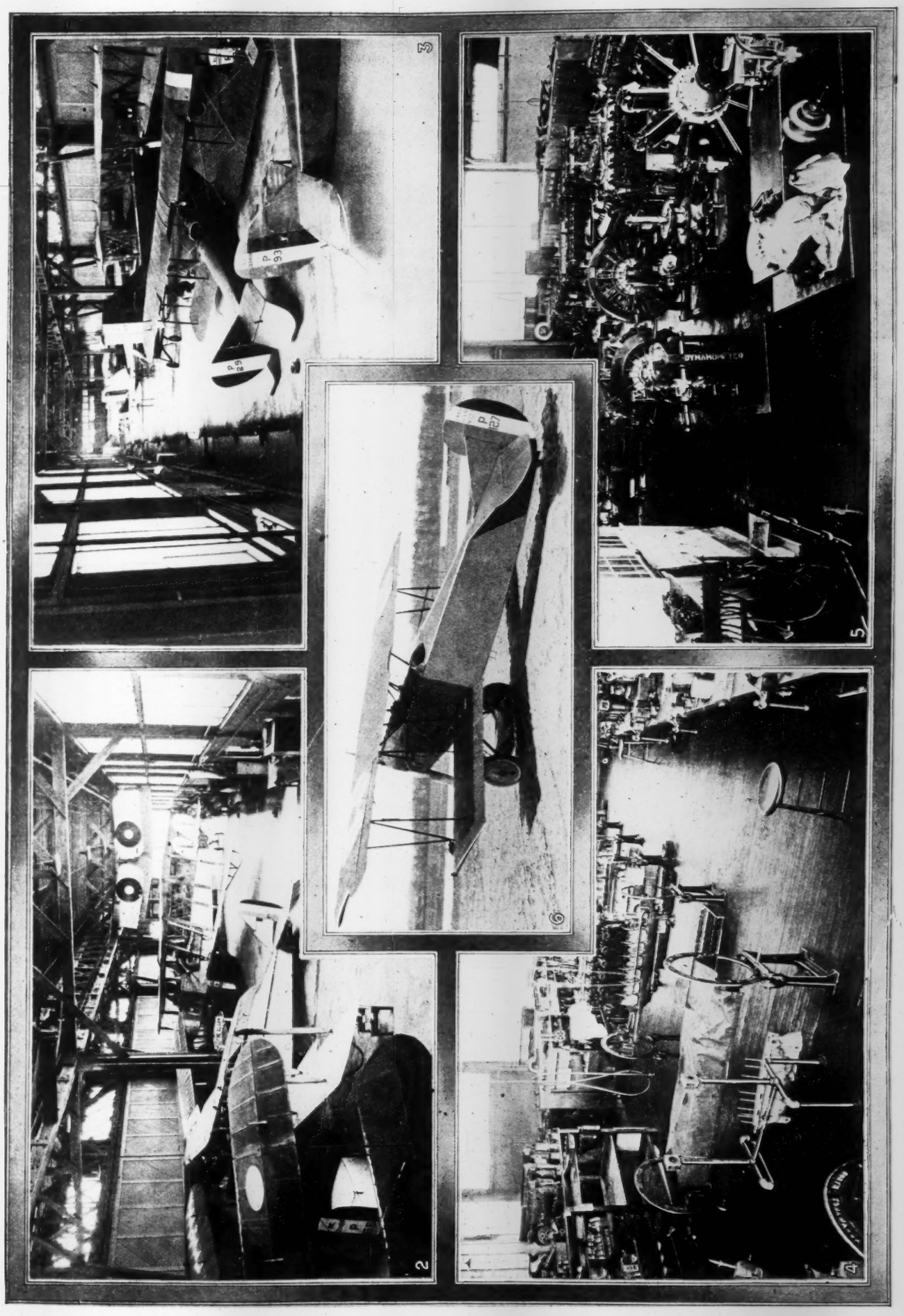


Fig. 2 View in Hangar Showing Machines Under Test
Fig. 3 View in Hangar Showing Machines Under Test
Fig. 4 Engine Overhaul Stands and Benches
Fig. 5 View Showing Interior of Engine Museum
Fig. 6 Fokker with Liberty-6 Engine

the present varied and highly efficient instruments for measuring and recording water and coal consumption, exhaust-gas analysis, temperatures at the various stages and other elements. But even these relatively highly organized methods of measurement appear crude when compared with the vast metrical work that is being carried on in connection with aeronautics. There man has projected himself into a world of which very little is known, and what little information is available is either incomplete or misleading. Everything about the air composing the upper strata of the atmosphere as well as about the vehicle in which man goes up into the air has to be learned anew, which means that new and precise instruments have to be developed.

The work of developing these instruments is being carried on vigorously at McCook Field and recently, for example, a new instrument was developed permitting the recording of altitude with a precision many times greater than has hitherto been possible. The time has not arrived, however, for telling more than what has just been stated regarding this branch of work, which, by the way, has a particularly great importance for the American aeronautical industry, as comparatively little is known about foreign developments in instrument manufacture since the armistice.

A good deal of the design work in connection with development of planes and their testing is also carried on at the Field, which has good facilities therefor. Likewise, important work is carried on in connection with the design of military accessories, but of this branch the less said the better.

Research Work in Altitude Flying

There is, however, one line of research which deserves particular attention. At the present writing a member of the McCook Field Flying Force holds the world's record for altitude flight, and, what is most important, altitude flying as carried out at the Field does not have the sole purpose of establishing records; as a matter of fact, the sporting element is kept entirely in the background.

For the Field, altitude flying is a grim business. They are developing the machinery to make altitude flying possible if the exigencies of war or aerial commerce should make it necessary. The flying is done with supercharged engines, which necessitate a number of inventions to make this new type of internal-combustion motor fully reliable to operate under the unusual and strenuous conditions prevailing at a height of several miles above sea level.

Then again, military authorities want to know just what is going on in the air at such altitudes, and it is already apparent that some of the phenomena occurring there are of vital and unexpected importance. They are not telling all they have learned and they should not. But one of the things which may be told is that winds of unsuspected velocities, ranging perhaps as high as 250 or more miles an hour, have been discovered blowing from west to east. Whether winds blowing in the other direction with similar velocities can be found remains yet to be seen, but even with the knowledge which we now have it appears perfectly feasible to go up in the air in California and land around New York within, say, 10 to 12 hours from the start.

Present and Future Potentialities of McCook Field

McCook Field, however, is more than a research organization of the War Department. If it is not so already, it nevertheless has a nucleus of the possibility of becoming what might be called a national post-graduate research laboratory in aeronautics.

There is one room in the Field (Fig. 5) which makes an engineer connected with aeronautical research think. This spacious, splendidly lighted room has on its floor practically every aeronautical engine of importance—Liberties of several types, the big Sunbeams, Gnome engines as dainty as a Swiss watch, a sturdy German Mercedes. All of these can be studied there and a visit may save months of research and trouble to any one connected with the design of aeronautical engines. It is certainly the most complete engine museum in this country, perhaps in the world, and one cannot help thinking what a splendid thing it would have been for American aeronautical engineering if side by side with the engine museum were other halls containing similar collections of propellers, wing sections and aeronautical accessories, and these backed by the courteous and expert staff on the Field. It may be mentioned, in this connection, that while there are sections of the Field closed to visitors as they should be, any person who can show a legitimate reason for inspecting those parts of the Field that do not fall under this restriction can easily obtain access to them. There is but little red tape about admission and the engineers and employees appear to be ready to help out any one expressing a fair reason for coming there. This is all the more worthy of note as the present staff is none too numerous for the work being done.

There is a good deal of talk now about Government assistance to aeronautics. The experience of France and England, for example, has shown that the art is yet too new and the commercial possibilities of aeronautics too limited and uncertain to develop without some form of Government assistance. Whether this will prove to be the case also in this country is a matter worthy of the most serious consideration. There is one form of Government assistance, however, the value of which will hardly be questioned, and that is assistance along the lines of research which no commercial concern can undertake.

McCook Field as it stands, together with the Aeronautical Laboratory of the Bureau of Standards, the Forest Laboratory at Madison, Wis., the testing fields of the Navy, already represents a powerful stimulus to the development of the art and science of aeronautics in this country.

A visitor to the Field cannot help being impressed with the fact that the actual coefficient of utilization of the Field is at present very low. The organization was conceived on a big scale in accordance with the vast American aeronautic problem of war time, and only a skeleton of it is maintained, and yet there is room and need for an organization even larger than that of the original McCook Field plan. In the field of aeronautical research undoubtedly good work has been done in this country, but the art is advancing by leaps and bounds and unless we keep up with it we are in danger of being left behind just as we were in the years 1914-1917.

It might be well, perhaps, to remember that the world's conditions are still extremely unsettled, and that it would really be a bold man who would dare to prophesy that this country will be confronted within the life of the present generation with an emergency similar to that of February, 1917. The development of aeronautical engineering as carried on by institutions like McCook Field is not a cheap proposition. On the other hand, however, it does not require any sums that might in the least prove to be burdensome to a country as wealthy as ours, and the value of such an investment would be repaid a thousandfold in many ways, especially if we should have the misfortune, together with the rest of the world, to be faced with a grave war emergency in the future.

The New England Pulp and Paper Industry

The pulp and paper industry of New England probably ranks third in money value of product; the textile and shoe and leather trades leading, but, from the traffic viewpoint, pulp and paper with the immense raw material tonnage involved in their manufacture easily lead all our industries. A "balanced" book paper mill, for example, involves about seven tons inbound for each ton of final product—a "balanced" mill meaning a plant producing its own sulphite and soda pulp and its own bleach and alkali by electrolysis. Thus a "balanced" mill with 250 tons daily product involves a total shipping tonnage of 600,000 tons per year.

With certain undoubted advantages for the manufacture of paper, New England also has some serious disadvantages. The mills have long hauls inbound on coal and many important raw materials of heavy tonnage, and outbound on much of their manufactured product. New England produces many times its own requirements of paper, and while the home market is important, and New York City is much the largest paper market on the continent, the center of consumption is very far west of there.

Pipe Lines for Transporting Natural Gas

The Construction, Repair and Operation of Jointed and Welded Lines, Including Particulars Regarding the Couplings Used, Pipe-Laying Machines, Strength of Welded Pipe, Pressure Regulation, etc.

By CLIFFORD E. BROCK[1], BARTLESVILLE, OKLA.

DURING the early development of the natural-gas industry many different styles of pipe and joints were used. The first line, a small wooden one, was laid in Pennsylvania in 1872. Small screw lines were next used, and these were followed by leaded-joint lines, which later developed into the rubber-gasket joint of the present day.

A coupling for plain-end pipe consists of a center ring *A*, two followers *B*, and two rubber gaskets *C*, as shown in Fig. 1. When laying coupling line, skids are placed across the ditch and the pipe, according to size and weight, is either carried or rolled on these skids. One follower, one gasket, and the center ring are placed on the first joint, and the other follower and gasket are put on the next joint, the latter being fitted into the center ring on the first joint. Bolts are then placed through the followers and are drawn up against the center ring, forcing the gaskets against the center ring and pipe and thus making a tight joint. After a section of line has been laid, it is lifted off the skids by means of short scaffolds or horses and lowered into the ditch as the skids are removed (see Fig. 2). Great care must be exercised in lowering coupling lines, or the joints will be strained and leaks develop.

Many different styles of couplings have been used, starting with cast-iron couplings, which make excellent joints but are too heavy and easily cracked if strained when the pipe is lowered into the ditch. Practically all couplings used today, however, are made of steel and with either outside followers, which fit over the center ring, or with inside followers, which fit under the center ring. See Fig. 1.

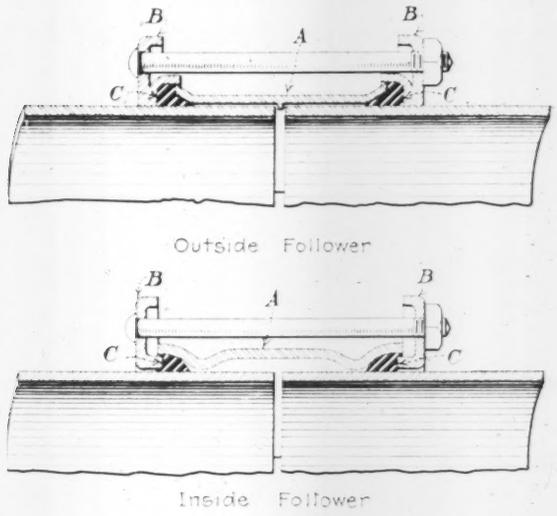


FIG. 1 TYPES OF COUPLINGS FOR PLAIN-END PIPE

It is the writer's belief that the outside-follower coupling is the most practical, for the reason that it is impossible for the rubber to blow out between the follower and the center ring; while with an inside follower a part of the rubber is pushed over the follower and there is nothing to prevent the rubber from blowing out between the follower and the center ring, in which case the gas flow cannot be shut off temporarily with wooden wedges while repairs are being made.

REPAIRING COUPLING LINES

Leaks on coupling lines occur from three different causes, namely, rubber blowing out, cracked center rings, or broken followers; and in case the leak is of any consequence it can be repaired without interrupting the service by installing an emergency sleeve over the coupling.

This emergency sleeve (Fig. 3) is made in six pieces, two large halves and four half-followers, which, when joined together, make a joint similar to a coupling. The large halves also have inside rubbers which make them gastight, as well as a relief valve located in the top half through which the gas flows while the repair is being made. When the repair work is completed the valve is closed, making a tight joint. The sleeves are left on until it is convenient to shut the line out to remove them and repair or replace the coupling.

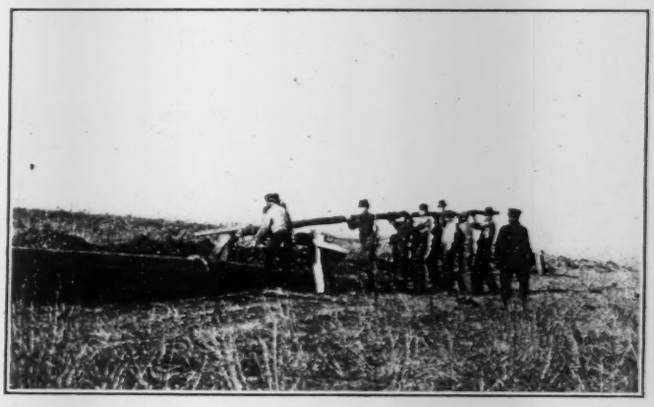


FIG. 2 LOWERING COUPLING LINE INTO DITCH

With the development of natural gas in the Mid-Continent field it was found that the rubbers heretofore used in coupling lines were affected by the gasoline in the gas, and after a short time were eaten out. About six years ago gasoline-proof rubbers were put on the market, and practically all lines laid with these rubbers have given very little trouble. These rubbers have a tendency to enlarge when saturated with gasoline, and in this way make a very tight joint. On a pipe-line system in California it was found that after a gasoline plant was installed, leaks occurred along the line due to shrinkage caused by the rubbers drying out, and it became necessary to bypass the gasoline plant occasionally and allow the rubbers to become saturated with gasoline until they had swelled sufficiently to shut off the leakage.

The great advantage in laying coupling line is the speed with which it can be laid. There is practically no limit to the amount of any size of plain-end pipe that can be laid in one day, except the number of men that can be employed on the work. While screw pipe will carry higher pressures than plain-end pipe, the following results obtained in tests show that plain-end lines will carry the high pressures employed with a good margin of safety:

Size, in.	6	8	10	12	16	18
Weight, lb.	17	24	32	42	48	53
Pressure, lb. per sq. in.	450	400	400	350	325	300

WELDED LINES

In the natural-gas business a large amount of screw pipe and casing becomes unserviceable after being used once or twice, unless it is rethreaded and new collars put on. To eliminate this expense by utilizing casing unfit for further employment in drill-

[1] Supt. Gas Pipe Lines, Empire Gas & Pipe Line Co., Jun. Am.Soc.M.E.

Presented at a meeting of the Mid-Continent Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Bartlesville, Okla., October 30, 1919.

ing, experiments in laying welded pipe lines were started in 1916.

Several small lines were laid in the Mid-Continent field, and gas men were so well pleased with the results that attempts at welding large lines were made. A 10-in. line was laid by the Wichita Pipeline Company from Drumright to Cushing, on which very few leaks have occurred since its completion. The Oklahoma Natural Gas Company laid a 10-in. line from Dilworth to Enid with good results, allowance being made for expansion and contraction by digging a wide ditch and blocking the line first on one side of the ditch, then on the other. Later the blocks were burned, leaving sufficient slack in the line to care for all the expansion or contraction.

In 1917 the Wichita Natural Gas Company laid a 12-in. line from the El Dorado field to Valley Center, Kan., but this line did not give as good results as the 10-in. line mentioned. A great many breaks occurred, and in places this line would pull apart three or four inches.

Another 12-in. line laid by the Empire Gas and Pipeline Company from Bigheart to Hominy, Okla., also gave considerable trouble, breaking as often as sixteen times in twenty-four hours.

All of the above-mentioned lines were laid without expansion

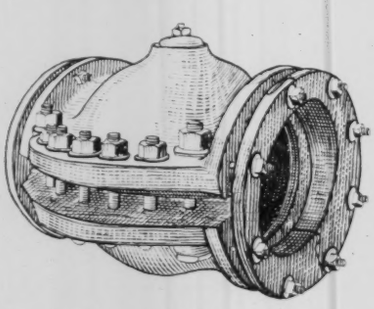


FIG. 3 EMERGENCY SLEEVE FOR REPAIRING LEAKS ON COUPLING LINES

sleeves or couplings, and after watching closely the operation of these lines, it is the opinion of the writer that it is impracticable to lay welded lines larger than 10 in. without allowing for expansion and contraction.

The process of laying welded lines must necessarily be slow on account of the time required to make a weld and the scarcity of good welders. The field is full of welders who are graduates of welding schools where they are taught to weld castings and flat steel, but these men must be taught how to weld pipe after they reach the job.

Large lines are usually welded in sections of six or eight joints before lowering into the ditch, and bell holes dug to weld the line solid. This process saves much time and digging, and gives the welder a chance to roll the pipe while welding rather than lay on his back in the ditch to weld the bottom of the joint.

The two principal welding irons used are vanadium steel and Norway iron, both of which are good, but better results are obtained with the latter on account of its being a softer metal.

The greatest drawback to welded lines is the great inconvenience and danger in repairing a break. It is almost impossible to repair a cracked weld with high pressure in the line, for two reasons: First, if the crack is very large, the gas pressure will be too great to permit the use of an emergency sleeve; second, if the top half of the sleeve is accidentally dropped on the pipe, the weld is likely to give away entirely, allowing a large volume of gas to escape and blow the top half of the sleeve and the men out of the ditch. In order to avoid such danger the writer has found it advisable to instruct all field men to always shut out and drain a welded line before attempting repairs, which of course would be disastrous to the service if the line were the only source of supply to the market.

The writer does not recommend welded lines in sizes larger than 8 in. without using a coupling or expansion sleeve every six or eight joints, but lines smaller than 8 in. can be laid successfully, and in connection work, such as Y's, tees, ells, etc., welded work can be depended upon and, if properly done, a great saving effected.

Excellent results have been obtained with the welding process in building meter stations, regulator stations, gasoline plants and refineries, in the construction of which it is necessary to do a large amount of pipe fitting, which, when threaded nipples and flanges are employed, is slow and expensive.

In pipe-line work it is more practical to use acetylene and oxygen in tanks on account of the necessity of moving often, but in stationary work an acetylene generator can be used and the acetylene generated at about half the cost when supplied in tanks.

Table 1 gives results of tests made by the Kansas City Testing Laboratory,[2] and shows the relative strength of the weld to the pipe.

TABLE 1 STRENGTH OF PIPE WELDS

WELDING ROD TESTS

Description	Elastic limit, lb. per sq. in.	Ultimate strength, lb. per sq. in.	Elongation, per cent in 8 in.	Reduction of area, per cent.	Per cent of elastic limit of pipe sample.	Per cent of ultimate strength of pipe sample.
Vanadium No. 1	46250	56870	11	75	....	....
Vanadium No. 2	75360	79600	10	75	....	....
Norway No. 1	42600	50300	35	60	....	....
Norway No. 2	63620	59200	20	75	....	....

PIPE AND WELD TESTS

Pipe Sample No. 1	48000	56360	22	40	....	....
Welded Sample No. 1	46350	54660	8	21	96	97
Welded Sample No. 2	38800	38800	0	0	81	69
Welded Sample No. 3	37600	41000	3	12	88.3	72.6
Welded Sample No. 4	31940	31940	0	0	67	54.5
Pipe Sample No. 2	42280	60080	22	40	....	....
Welded Sample No. 1	39400	44620	3	16	93.5	74.3
Welded Sample No. 2	38680	42800	3	12	91.5	71.4
Welded Sample No. 3	38080	51190	5	18	90.1	85.3
Welded Sample No. 4	33950	47750	6	11	80.2	74.1

SCREW LINES

Screw lines are laid by two different methods, by hand and by machine. In laying pipe by hand, one of the gang, known as the "stabber," starts the joint pipe into the collar of the preceding joint, and rolls it by hand for several threads to see that it is not cross-threaded. The joint is then screwed up as far as possible with a snubbing rope, and tongs are used to tighten it. These tongs are provided with a square key let into the shorter jaw crosswise, the exposed corner serving to grip the pipe, and this key can be very easily turned to expose a fresh corner or replaced. Before laying screw pipe the threads should be oiled with a heavy oil or pipe dope, which will aid in screwing up the joint and will also preserve the threads and make the joints easy to break when reclaiming a line.

Screw-connection work where only flange unions are used is a very particular job, requiring great patience and accuracy, but when completed makes the best connections. However, a large amount of screw-connection work is finally connected with a solid steel sleeve similar to a plain-end coupling but of greater length, to allow for expansion or contraction.

Several machines are manufactured by means of which it is possible to lay screw lines by power. This method is much faster than laying with tongs, but requires careful supervision to avoid screwing up a joint cross-threaded or burning the threads by running up a joint too fast.

PIPE-LAYING MACHINES

The two pipe machines most used in the Mid-Continent field are the "Buckeye" and "Mahoney," or California pipe machine. The Buckeye machine moves on caterpillars, and the pipe is laid

from its rear end. The Mahoney machine is not equipped with caterpillars but moves on the pipe by means of a traveling gear operated by a clutch. When a joint has been laid a jack is placed under its head end and the machine moves forward to the end of the joint by means of the traveling gear. The machine is also equipped with a jack on which it is raised by power to take the weight off the pipe while another joint is being screwed up. Two sets of tongs are located on the front end, one for back-ups to hold the joint previously laid, and another to tighten the next joint. When it is desired to make an over-bend in the pipe, it is merely necessary to place a jack under the pipe at the point where the bend is to be made and run the machine ahead far enough to give the desired weight to make the bend. An attachment may also be purchased for these machines with which it is possible to make a sag bend in the pipe. This is done by the use of a 10-ton hydraulic jack operated by power from the motor. A force of fifteen or twenty men can operate the Mahoney machine, and where the country is fairly level a great deal of time can be saved, as it is possible to lay from thirty to forty joints an hour.

Screw pipe, while used in laying small gas lines, is used exclusively in laying oil lines, as a much higher pressure can be maintained on a screw line than on a coupling or plain-end line, and after a time rubbers in a coupling line will become affected by the oil. There is also considerably less friction in a screw line than in a coupling line, due to the different design of the joints.

General

In laying gas pipe lines there are many details which aid efficient and continuous operation of a line.

When connecting wells in a field it is always good policy to install a check valve at the point where the well line connects to the main line, to avoid a loss of gas in case of a break in the well line, or gate or tubing in the well.

In fields where salt water or gasoline is encountered with the gas it is necessary to install traps or drips to catch the fluid before it reaches the main line, as fluid affects measurement of the gas, regulation of pressure and operation of compressing stations, and at times even reaches the consumer's meter. A great many different types of drips have been designed, but all perform in practically the same manner—that is, they allow the gas to expand and decrease in velocity, which causes precipitation of the entrained fluid.

When constructing a main pipe line it is advisable to install a main-line gate every four or five miles, with a relief valve and pressure-gage tap on each side of the main-line gate. When a line is so laid it is possible, in case of a break, to shut out a short section of the line and exhaust the gas through the relief valves without draining the entire line and discontinuing service to consumers on sections of the line not affected by the break. With the gage taps it is possible for the man supervising the repair to observe the pressure being maintained on either side of the break.

In constructing river crossings for pipe lines which must give continuous service, it is always advisable to lay more than one crossing. The lines in the river can be of smaller pipe than the main line, but the total capacity should equal that of the main line. River crossings should be laid in deep water when possible, as the greater depth will lessen the danger of having the line torn out by drift. A line should never be laid straight across a stream, but swung in an arc upstream, the radius of the arc varying with the length of the crossing. In this manner the resistance of the line is greatly increased and many breaks avoided.

River lines are usually laid of screw pipe and each collar covered with a river clamp (Fig. 4), which removes all strain from the joint and adds weight to the line.

Occasionally welded river crossings are constructed, and in this case a split emergency sleeve, or a river clamp which has a rubber packing similar to that of an emergency sleeve, should be used, as it would be impossible to repair a welded crossing without first removing it from the water or without constructing cofferdams.

Operating a Pipe-Line System

In operating a gas pipe-line system it is good practice to carry the lowest pressure with which it is possible to handle the market, and in cases where small towns are located some distance from the main line and are supplied by smaller lines, regulators are installed at the main line and the pressure reduced rather than carry main-line pressure to the town limits.

In the operation of a natural-gas system it is impossible to turn in all gas available and allow it to go where it will, as the consumers on one part of the system would have an oversupply of fuel, while those on another part would suffer from shortage. To avoid such unequal service, gas companies maintain what is usually known as a dispatcher's office. Here pressure reports are received by telephone from all important points on the system at certain intervals during the day, and by carefully tabulating and observing these pressures, it is possible by regulation of the gas to maintain sufficient pressures throughout the entire system. In case of line breaks or line shut-outs for any reason, the field men are required to notify the dispatcher's office before a line is taken out of service in order that the service may be maintained by supplying from another source. In fact, the duties of a pressure dispatcher parallel those of a train dispatcher, and all wells, lines and regulators are operated upon orders from him.

In the operation of a pipe-line system the entire effort of the organization is devoted to giving continuous service, and in order to do this men are stationed at various places along the system.

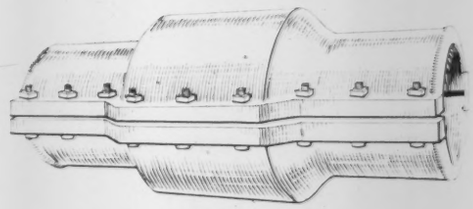


FIG. 4 CLAMP USED TO COVER COLLARS OF SCREW-PIPE RIVER CROSSINGS

The lines are patrolled continuously by line walkers, who repair small leaks as they find them and report to their immediate superior leaks which they cannot repair. In such cases a crew is taken to the leak at the earliest possible moment to make the repairs.

It is seldom realized that while many homes are comfortably warmed by natural gas, it is often necessary for pipe-line repair gangs to be out night after night working to keep the lines together and prevent gas shortage. In fact, the gas consumer seldom hears of a break or leak on the gas line from which he receives his supply, due to the efficiency which must necessarily be maintained in a pipe-line organization.

The methods employed during the war of applying the electrodeposition of iron to the repair of motor vehicles were described recently before the Institution of Automobile Engineers by Mr. B. H. Thomas, who instituted the process. It was found possible to deposit a layer of iron up to about 2mm. in actual thickness on any simple cylindrical surface of wrought iron or steel, mild or cast. If the work is properly done this layer is firmly adherent, and it is practically impossible to chip it away with hammer and chisel from the basis metal. It is deposited direct on the surface without preliminary coppering, and can be subjected to red heat without apparent deterioration. It can be carbonized and hardened in the ordinary way. The layer presents an extremely smooth surface, and the thickness put on in a given time can be predicted with considerable accuracy. It can be filed or ground, and takes a high finish. It is perfectly satisfactory on such parts as brake and clutch shaft ends and starting handle spindles, and there is no obvious reason why it should not be satisfactory for building up worn journals.

The Engineer and the Woodworking Industry

A Great Industry in Which There Exists an Urgent Need of Engineering Skill

By THOMAS D. PERRY,[1] GRAND RAPIDS, MICH.

The lack of the application of engineering principles and practice to the woodworking industry has been felt very strongly by a group of Grand Rapids members of The American Society of Mechanical Engineers. One of these, Mr. Thomas D. Perry, has prepared the following article, outlining the scope of woodworking field and presenting some of the engineering problems involved, with a view of opening the subject for discussion and as a preliminary to a possible session on woodworking at a later meeting.—EDITOR.

WOODWORKING, one of the oldest civilized trades, is now one of the largest industries in the United States. It is doubtful whether any other major group of modern manufacturers gives evidence of less scientific knowledge of its products. The reason for this is quite apparent.

Agriculture has been very slow in adopting scientific means to improve the efficiency of its workmen because son could easily follow father with no special training. Carpenters' sons could do likewise; hence, a few branches of rudimentary woodworking were not at all difficult to acquire. In each case one or two or a half-dozen men could complete the finished product and no extensive organization, capital or costly machinery was necessary.

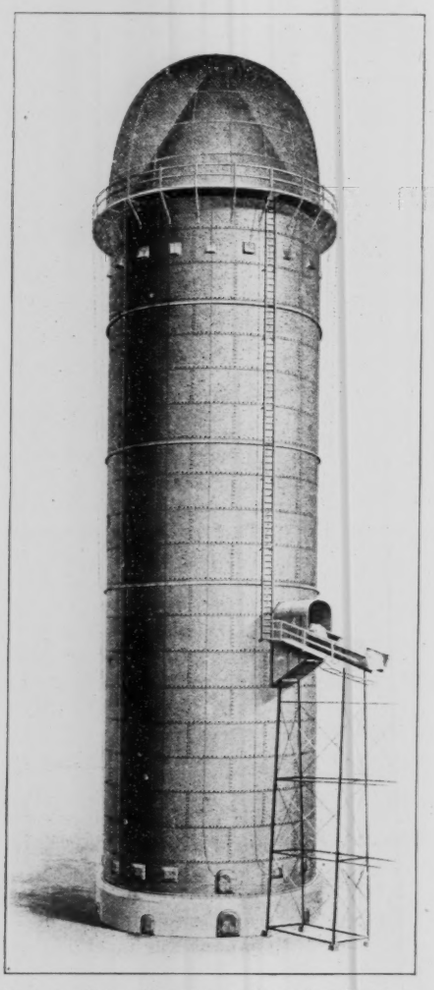


FIG. 1 THE MUSKEGON REFUSE BURNER

The problem of the metal worker was far different. The necessary processes were complex and expensive. They demanded skill for the many necessary steps between the iron ore and the rolled boiler plate or the seamless boiler tube. It was therefore quite natural that the engineer was attracted to the intricate and involved problems of the metal worker, and that the metal worker, in his turn, felt the need of the trained scientist.

A survey, no matter how superficial, will demonstrate that, while the woodworker may not have needed the engineer in the past, he certainly needs him now. Raw material is increasingly more valuable; and wasteful methods are increasingly more culpable; labor requires higher wages; mechanical methods are in demand; manufacturing units are larger; need for coördination is more pressing; and output is more standardized. Proper adjustments to meet these conditions will permit larger and more intensive production.

The woodworker is by no means wholly to blame for not desiring or utilizing engineering knowledge. The engineer seems to have considered that such simple problems as those of the woodworker were beneath his dignity and not worth while. It follows, therefore, that if the woodworking industry and the engineering profession are to be of mutual benefit, a broader aspect and a complete readjustment of attitude are necessary.

It may be of interest to enumerate a few of the branches of the woodworking industry and suggest a few of the problems that need better solutions. The fundamental division is between primary woodworkers, converting timber and logs (natural growths) into lumber or some other form of raw material intermediate between the tree and the final product; and secondary woodworkers, who take the lumber and make it into pianos, furniture, caskets, house trim, etc. The problems are quite unlike, although there may be a few exceptions where the primary manufacturer still produces the finished product, as in the case of cooperage and flooring and many kitchen implements made directly from the log.

The sawmill operator has the problem of bringing logs to the mill, which includes hill and valley logging, land and swamp skidding, rail and water hauling, all more or less complicated by the rotation of the seasons and the variations of the weather. Considerable engineering skill has been shown in some of these problems, mostly, however, in the direction of machine design. The utilization of waste in such plants stands out as a gigantic travesty on the principles of economy. It is frequently said that steam power does not cost the sawmill man anything because he has plenty of waste, therefore, why watch the economies of steam consumption!

Nearly every sawmill has a large waste burner (Fig. 1) to consume the refuse so that the burning of the waste will not be an undue hazard to mill buildings and lumber yards. Temperatures of 800 deg. are not unusual in these burners. The better class of waste is put under the boilers and the remainder in the waste burner, by means of which untold potential power is dissipated. The waste from trimming trees in the woods is left where it offers fuel for forest fires. In a few instances the author has known of the utilization of mill and woods waste for power production such as the manufacture of artificial ice in southern states and for making wood fiber for wrapping papers. These few instances, however, are exceptions to the rule of universal and unjustifiable waste in lumber production.

The rotary cutting, slicing and sawing of veneers is subject to all of the above problems, and in addition has several refinements such as preparing, cutting and handling thin and delicate sheets, selecting for figure, preventing discoloration, keeping flat, etc.

Another question, which needs the attention of the engineer is that of artificial drying. The problem of establishing the conditions of heat and circulation are not so difficult, but the tendency of the wood to dry too rapidly on the surface and establish

[1] Vice-President and Manager, Grand Rapids Veneer Works.

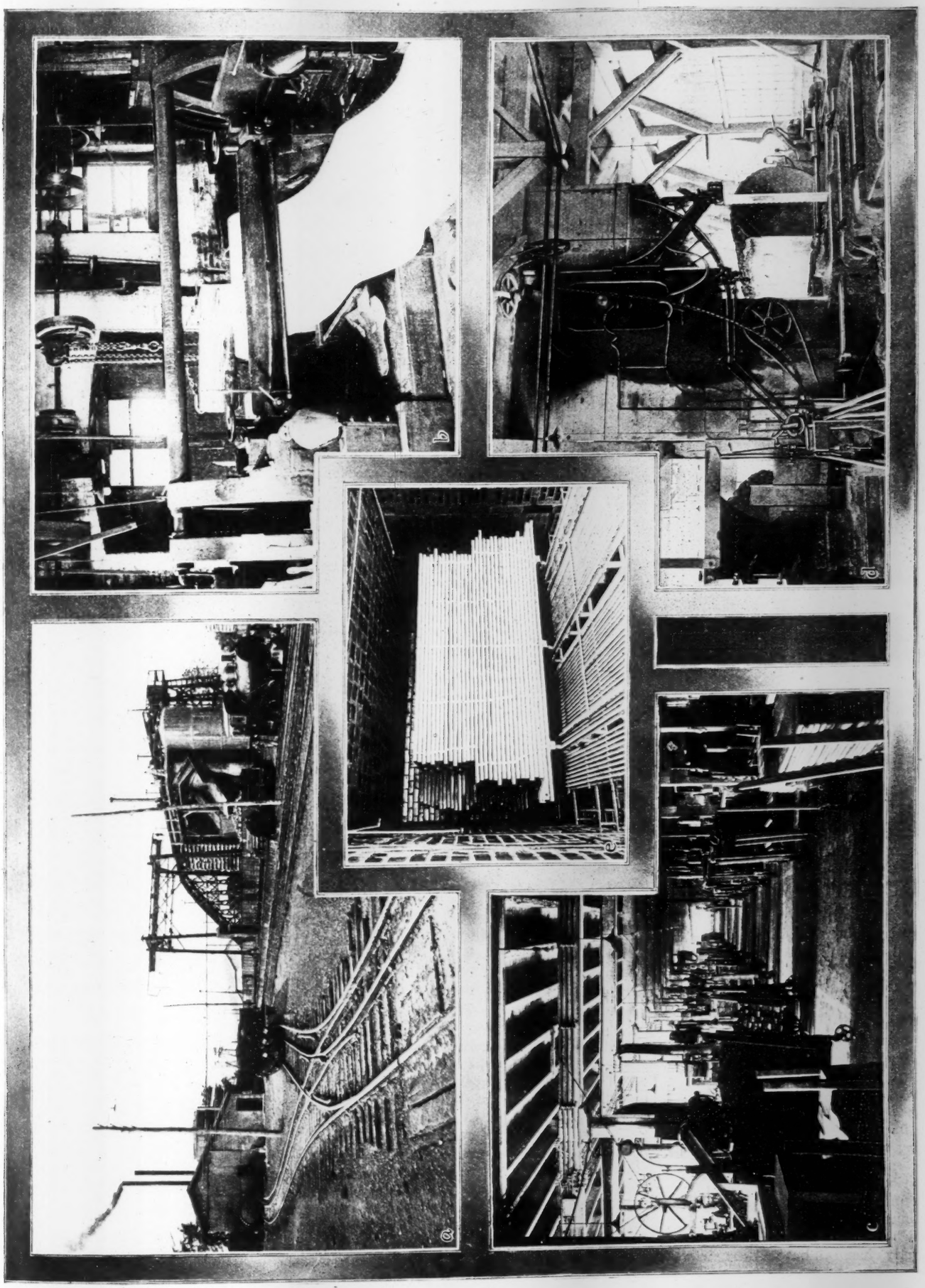


FIG. 2 TYPICAL VIEWS IN WOOD-TREATING AND WOODWORKING ESTABLISHMENTS

(*a*) Typical view of wood-treating plant, showing at the left a horizontal cylinder for treating ties and timber, at the right a vertical cylinder for treating paving blocks, with a gantry crane between them for handling cross ties and lumber, and at the extreme right a steam storage locomotive. (*b*) Rotary veneer cutting from basswood log at the plant of the Grand Rapids Veneer Works, Grand Rapids, Mich., using Coe lathe. (*c*) Typical interior of modern Grand Rapids furniture factory, showing center trucking aisle with machines located near windows. (*d*) Typical sawmill installation on the Pacific coast. (Copyright Cress Dale Photo Co., Seattle). (*e*) Interior of a Grand Rapids vapor kiln of the box type; one of a battery of 14 at the plant of the Packard Motor Car Co., Detroit.

internal strain is usually overlooked. Fig. 3 shows a typical specimen of lumber drying: the cross-section of this board shows a wet center and a dry surface. The establishment and maintenance of a proper degree of enveloping humidity is the most difficult part of the drying operation, usually not appreciated by engineers. Of the various systems on the market each has its advantages: the blower types for veneer, finishes, glued work, etc., where there is no great thickness to be dried; the condensing kiln for the very thick and green lumber where plenty of time is available and careful operation possible; the ventilating type for speed and efficiency in the average plant of the majority of lumber producers and consumers. Artificial drying for piano actions, phonograph horns, and high-grade furniture requires a more refined process than that of general lumber drying. The opportunity for research and practical investigation along these lines is very great.

Cooperage, or the making of barrels, kegs, tubs, pails and casks, is in a very primitive condition and would completely discourage any engineer who might assume the problem of developing it. In a tight barrel the staves are first baked dry in a kiln, then machined to size and then assembled in barrel form and hooped

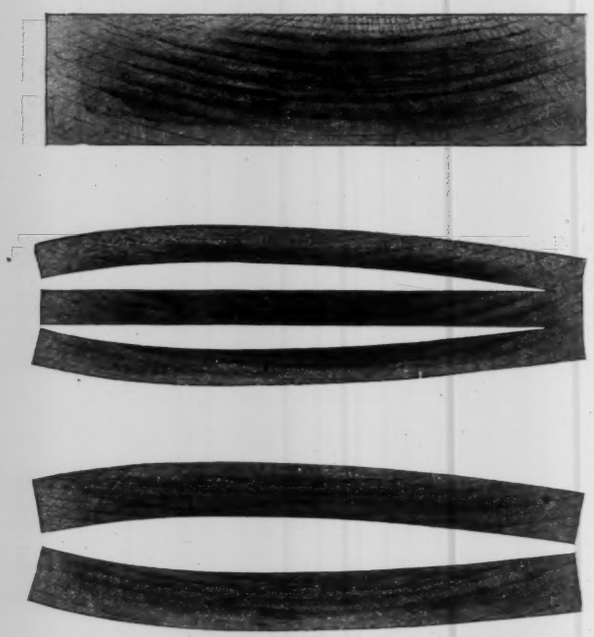


FIG. 3 CROSS-SECTIONS OF UNEVENLY DRIED BOARD WITH MORE MOISTURE IN CENTER THAN ON OUTSIDE SURFACES

The two lower sections show the effect of resawing this board and releasing the internal strain. The big problem in lumber is to dry without internal strain.

for one-third of their length. The next operation is steaming to soften and render the assembled staves pliable so that the bulge of the barrel can be produced. When the hooping operation is completed the barrels, without heads, are set over little fires to again bake them dry. This process is only typical of others as crude.

The impregnation of woods with various preservatives has received some engineering encouragement, perhaps because the creosoting of ties has been so intimately connected with railroad engineering. Very light woods used for life preservers need an "eneysting" process to prevent rapid mold and rot. Woods used for insulation require similar retardents against decay. Fireproofing treatments to make wood shingles less inflammable are in the same class. Sterilizing treatments are necessary to destroy various fungus growths in warm climates, such as the blue stain in pine timbers. Woodwork to be sent to oriental countries must be made unattractive to the multitude of insect borers which attack nearly all untreated woods. The solution may be partly chemical, but it is certainly well within the broader engineering scope.

The making of wood pulp is an example of wood utilization developed through engineering skill, but it happens to be a process that is complicated and demands large production units.

The strength of timber of various species has been the subject of many tests under varying conditions, but a recognized standard compilation does not exist. The airplane has brought this subject prominently to the front, because the life of an airman or the success of his military mission would frequently depend on the reliability of wood parts. This phase of strength, recognized in only two of many uses, offers a vast field for consistent investigation and comparative study. What relation has density, or frequency of growth rings, or heart and sap wood to strength and elasticity? The authorities are few and their conclusions far from final. The tip of an airplane propeller moves at the rate of five miles, or 26,000 ft., per min. How can wood be made to endure this strain?

Wood is used in automobiles for spokes, felloes, bodies, top bows, dash boards, foot boards, running boards, battery parts, and sometimes for the all important work of distributing the weight of body and engine on the axles. Authorities vary widely as to the merit of wood and steel wheels, and as to the relative comfort and durability of wood and steel trusses from body to axles. No conclusive authority exists for intelligent guidance.

Production methods or industrial engineering are hardly developed as yet in the woodworking industry. Factory equipment and systems are largely lacking in productive efficiency. The application of production processes which have proved successful in other lines than woodwork is hardly to be regarded as more than experimental in such a new field. The average woodworker has very little regard for the production engineer at the present time. However, there are developing here and there unrelated and uncoördinated examples of scientific factory production. What better service could be rendered by engineers and engineering publications than to assist in standardizing and disseminating the best results? A few firms are specializing in this work, but there is available no supply of trained men from which to recruit their staffs of workers.

The public schools of this country have been struggling with the sloyd or so-called manual training in woodworking branches for many years, but where is an institution that produces even the rudiments of a woodworking training? Even the Massachusetts Institute of Technology has next to nothing to offer except patternwork and tests on strength of lumber. The forestry schools, notably the New York State College of Forestry at Syracuse, are making a beginning, but employers do not realize the need of sending their men for even short courses. Recent attempts to draw from the whole state of New York for a six weeks' course in kiln engineering resulted in less than a dozen pupils for the second year's trial, and the first year brought even less response, which did not warrant carrying the course through.

The foregoing is far from exhausting the list of the many opportunities in woodworking for suitably trained engineers. The demands for recreation and amusement require golf clubs, ball bats, billiard equipment, bowling-alley equipment, dominoes, checkers, chessmen, and gun stocks, all of which call for manufacturing efficiency in diverse lines.

The domestic equipment of the average home embraces matches, toothpicks, clothespins, cutlery handles, churns, calorie cookers, hollow woodenware, rolling pins, potato mashers, broom handles skewers, and many other articles. Each is made in sufficient quantity to occupy many factories and employ hundreds and often thousands of workmen.

Airplanes and automobiles are not the only vehicles of transportation that use wood in large measure. There are wagons, buggies, freight cars, passenger cars, boats and ships in which strength and durability are absolutely essential in material, design and fabrication.

The field for the engineer in woodworking is almost unlimited, but the development of such a new and untried line will take education, patience and adaptability on the part of all who are vitally interested in the trades that employ so large a proportion of our citizens.

An Investigation of Compressed-Spruce Pulleys

By GEORGE S. WILSON[1], SEATTLE, WASH.

WITH the view of determining the practicability of manufacturing pulleys from native spruce, a series of tests was conducted in the Mechanical Engineering Laboratories of the University of Washington. These tests extended over a period of nine months from July 1, 1919, to April 1, 1920, and the investigation included the following:

a Determination of some of the factors influencing the carrying capacity of compressed-spruce pulleys.

b A comparison of compressed-spruce pulleys with other commercial types.

The work was undertaken at the request of Watts & Walsh, of Tacoma, Wash., manufacturers of compressed-spruce power-transmission and conveying equipment, to whom much credit is due for assistance given in conducting the tests.

The tests were made with single-ply leather belting 4 in. wide by 0.225 in. thick or 0.9 sq. in. in cross-section. The pulleys were nominally 18 in. in diameter and 6 in. face. A constant speed of 2000 ft. per min. was maintained.

In general, the tests consisted of sets of observations on belt slips (slip includes creep) at different initial belt tensions and varying brake loads. Five different initial tensions were used in each set (37½, 75, 112½, 150 and 187½ lb. per sq. in. of belt section), and the load varied from a minimum to the maximum that the belt would carry or the capacity of the driving motor would allow.

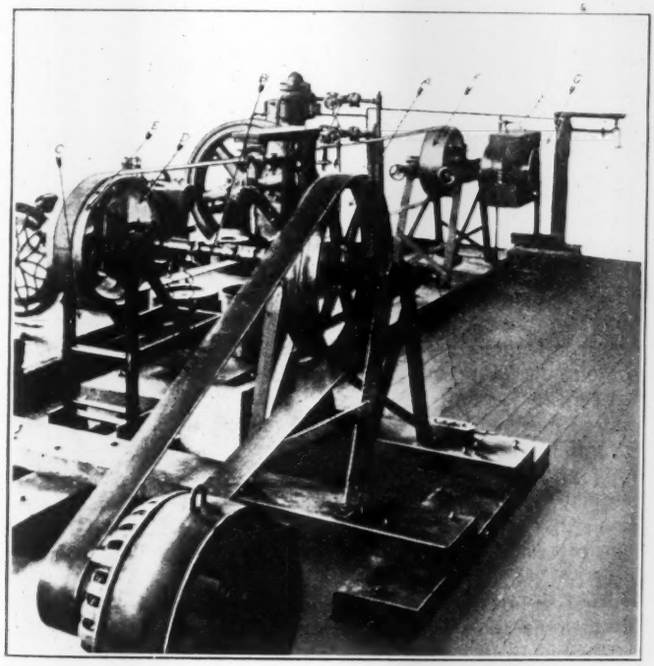


FIG. 1 MACHINE USED IN PULLEY TESTS AT UNIVERSITY OF WASHINGTON

The machine used in the tests was built for the Mechanical Engineering Department of the University of Washington. Fig. 1 shows the general arrangement, *A* being the driving pulley, *B* a universal coupling, *C* the tension-weighing device, *D* the arc-of-contact meter, *E* the driving test pulley, *F* the driven test pulley, and *G* the Prony brake and tension-adjusting device.

The slip meter used consists of two cams, on the driving and driven shafts, respectively, each of which makes contact with a spring brush once each revolution. When the cams are in phase an electric circuit is closed through the contacts and a lamp flashes once each revolution. As the driven shaft lags behind the driving shaft, however, the cams gradually get out of phase and the light goes out until the driven shaft has dropped one full turn behind the driving shaft, when it starts flashing again. To determine the slip a continuous counter, operated by the driving shaft, was started at the first light flash and allowed to run until the light had died out; when the light again began to flash, the counter was stopped. The reading obtained was the number of revolutions made by the driving shaft for the loss of one revolution of the driven shaft.

After considerable preliminary experimenting it was decided that a 70 per cent end-grain spruce pulley built with about ¼-in. laminations and compressed under 250 tons total pressure, with the face properly crowned, smoothly finished and coated with high-grade shellac, should be used in a comparative series of tests with steel, split wood, paper and cast-iron pulleys. Fig. 2 shows the pulley selected.

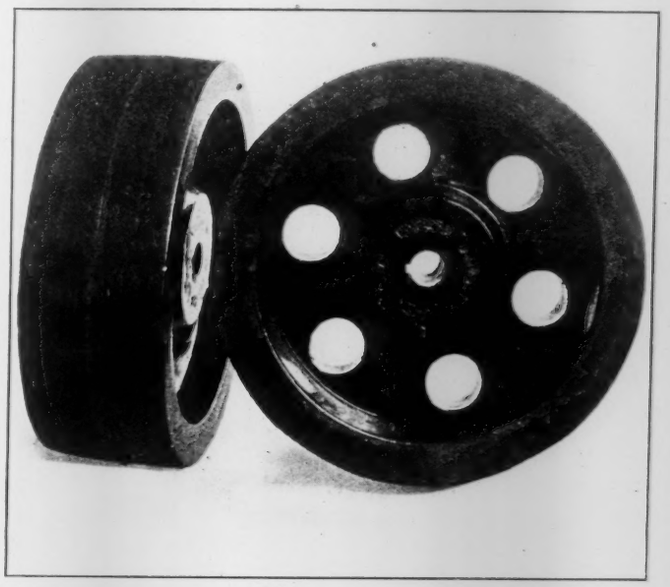


FIG. 2 COMPRESSED-SPRUCE PULLEY EMPLOYED IN TESTS (¼-in. laminations compressed under 250 tons total pressure)

In the comparative tests the driving motor used was not sufficiently powerful to load the pulleys to their maximum capacity, but the curves in Figs. 3 and 4 show the results within the load limits. It will be noticed that for belt slip below 2 per cent the variation in the capacity of the different pulleys is small, with the exception of the cast-iron pulleys, which have the lowest capacity of any of those tested.

TABLE 1 HORSEPOWER CAPACITIES OF PULLEYS PER INCH WIDTH OF BELT

Pulley	Slip, per cent			Comparative transmitting capacity at 2 per cent slip
	1	1.5	2	
Cast iron	0.58	0.69	0.74	100.0
Steel	0.71	0.78	0.81	109.4
Wood, split	0.63	0.77	0.82	110.8
Paper	0.62	0.76	0.83	112.1
Compressed spruce	0.76	0.81	0.84	113.5

Beyond the 2 per cent slip range the variation in capacity is probably greater. In all cases the capacity will be affected by the amount of crown on the pulley, the finish of the pulley face, and the condition of the belt and belt lacing.

While Figs. 3 and 4 furnish the engineer a definite measure

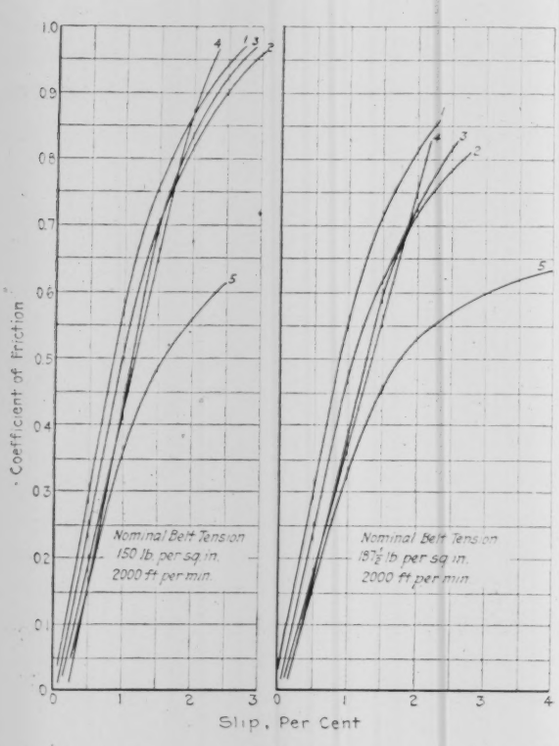
Abstract of a paper presented at a meeting of the Washington State Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Seattle, Wash., April 19, 1920.

[1] Associate Professor of Mechanical Engineering, University of Washington. Mem. Am. Soc. M. E.

of pulley capacities, Table 1, which gives the horsepower per inch width of belt, will probably better serve the needs of the average pulley user. This table is calculated from Nagle's formula, assuming a belt contact of 180 deg., a belt thickness of 0.225 in., a belt speed of 2000 ft. per min. and a stress of 200 lb. per sq. in. of belt section; values of the coefficient of friction were taken from Fig. 4.

Since the weights of pulleys may be a factor in some installations, the pulleys tested (all 18 in. diam. by 6 in. face) were weighed, with the following results:

Pulley	Cast Iron	Steel	Wood, Split	Paper	Compressed Spruce
Weight, lb.	65	40	24.5	41.5	22



FIGS. 3 AND 4 FRICTION-SLIP RELATIONS FOR VARIOUS TYPES OF PULLEYS

Pulleys: 1, Compressed Spruce; 2 Steel; 3, Wood, split; 4, Paper; 5, Cast Iron. Belt speed, 2000 ft. per min.

Table 1 and the foregoing weights show that the compressed-spruce pulleys as now developed are at least as serviceable as any of the ordinary commercial types.

STANDARDIZATION OF FIRE-HOSE COUPLINGS

THE state-wide movements in several states of the Middle West toward the adoption of National Fire Hose Couplings, reveal the fact that this problem of standardization is fast becoming one of nation-wide importance. Failure to recognize it as such in the past has resulted in enormous fire losses which have been due in no small measure to the lack of uniformity in fire-hose couplings in adjacent cities and towns.

The first real movement for standardization may be said to date back to the great Boston fire of 1872. Following this conflagration several of the near-by cities, profiting by the experience, adopted the Roxbury thread coupling which was the Boston Standard at that time. Later New York City adopted a thread which became the local standard through general adoption by most of the New Jersey and New York State municipalities within a radius of from 50 to 75 miles. Local standards have been adopted in a number of places which have given a feeling of security and complacency. Experience has shown, however, that such an attitude is not entirely justified because of the fact that outlying towns are little better off than if there were no standards at all.

The first organized effort toward the adoption of a universal standard thread was made by the International Association of Fire Engineers during the period 1873-1883. It was not, however, until a Committee on Hose Couplings and Hydrant Fittings of the National Fire Protection Association was appointed in 1905 that the work was effectively started. Through the efforts of this committee the couplings known as the National Standard promptly received unqualified approval and adoption by all of the leading organizations concerned with fire protection and by many municipal fire departments. Coincidentally The American Society of Mechanical Engineers appointed a sub-committee on fire protection whose report (Transactions No. 1398, Volume XXV, 1913) describes the methods by means of which the standards were adopted, the specifications for hose couplings, and the methods for converting non-standard couplings.

In December 1919 an illustrated pamphlet, Standardization for Fire Hose Couplings and Fittings, containing an extended treatment of the subject of this standardization, and a complete description of the resizing or standardization tools, was issued by the National Board of Fire Underwriters of New York City. Upward of 12,000 copies of this pamphlet have been distributed among water works and fire-department officials, state fire marshals, insurance commissioners and other interested organizations. This pamphlet, copies of which are still available, contains a description of a set of tools devised for the purpose of reforming to standard size, threads which are slightly different from standard.

There are about 8000 cities or towns in the United States and Canada that have fire-hose fittings in service. Statistics show that 15 per cent of them have National Standard thread couplings; 70 per cent have couplings that may be resized and made standard, and the remaining 15 per cent are either using couplings which have six threads to the inch or one of the various types of snap or clutch couplings.

Because of the progress in adopting the National Standard Coupling made by the state of Indiana, this state has been recognized as a pioneer in the field of state-wide adoption. As a result of the satisfactory demonstration of a set of resizing or standardization tools on the undersized fittings of the town of Thornton, the oversized fittings of Lebanon and a variety of threads in the headquarters of the Indiana Fire Department, the organized movement for state-wide adoption was initiated. According to the latest statistics, 13.5 per cent of Indiana towns are already using standard threads, and 70 per cent have threads which may readily be made standard, but in the case of the remaining 16.5 per cent it is believed that the best results will be obtained through complete replacement of the fittings now in use.

It has been estimated that the above-mentioned 70 per cent of Indiana towns and cities can be completely standardized in eight months by keeping in continuous use six complete sets of resizing or standardizing tools. It can readily be seen that the cost of the entire work is small as compared to the advantages to be derived from the elimination of confusion and delays due to the existing misfits.

Similar state-wide standardization movements have been instituted in Kentucky, West Virginia, Minnesota, Michigan and Illinois, and the added interest made manifest at recent demonstrations of the resizing tools and the number of inquiries received at the office of the National Board of Fire Underwriters in New York, clearly indicate that this long-desired movement toward standardization and conservation will, in the near future, attain nation-wide magnitude and importance.

The American Society of Mechanical Engineers has supported this movement from its inception and, as a body, is much interested in the recent strides toward its general adoption. Members who reside in localities where standardization movements have not already been initiated, are urged to take upon themselves the matter of arousing their respective communities to the importance of the subject.

ENGINEERING SURVEY

A Review of Progress and Attainment in Mechanical Engineering and Related Fields, as Gathered from Current Technical Periodicals and Other Sources

SUBJECTS OF THIS MONTH'S ABSTRACTS

Stevens Super-Power Station
General Electric Design of a Super-Power Station
Economics of Power Generation
Report of Committee on Prime Movers of the National Electric Light Association
Explosion Gaps in Large Power Stations
Steam Turbine, Double-Cylinder Extraction and Low-Pressure
Steam Turbine, Power-Producing, Pressure-Reducing
Super-Power Zones in New England
High-Pressure, High Superheat Steam Plant
Power Plants, Distribution of Fuel and Water Consumption
Balancing Turbine Rotors
Gear Erosion
Condenser Tube Corrosion
High Steam Pressures
Pulverized Fuel
Water Purification in Power Plants
Radiators for Aircraft
Air-Duct Design (Chart)
Viscosity of Oil Blends, Saybolt
Metal Substitution in Germany During War
Coke Breeze on Underfeed Stokers
Heavy-Oil Engines, Fuel Injection
Automobile Engines, Limits of Slow Running in
Graphite Lubricants
Cams for Radial and Rotary Engines
Bicycle Chains
Rolled Products of 99 per cent Nickel
Bearings, Radio-Thrust, Load Characteristics
Locomobile, Compound, with Superheater

The Stevens Super-Power Central Station

OF the many remarkable changes in the life of the people and in the industries of the world during the past 30 or 40 years, none has been more profound than the rapid increase in the consumption of mechanical power. A man of two-score years ago consumed very little mechanical power. His food and supplies to a large extent came from nearby neighborhoods, brought by horse-drawn vehicles. He did comparatively little traveling, his home was lighted by kerosene lamps, and in most towns his water was pumped by hand from wells or drawn from springs. Many hand-made articles were in daily use and those which were produced in factories involved hand operations which have since been superseded by machine operations requiring the use of power.

The man of today, however, at every step is directly or indirectly a large consumer of power, from the moment he gets up and turns on the water for his bath to the time when on retiring he turns off the light and thus relieves the load on the lighting plant of his own town. Not only has there been a great increase in the multiplicity and variety of manufactured articles, but there has been a corresponding growth in transportation and illumination. Raw materials, food supplies and produce are brought from all parts of the world, and manufactured products are as widely distributed. The great systems of electric transportation and electric illumination have come in, taking power from immense central stations, and the automobile is made by the million in plants with thousands of power-driven machine tools.

It is obvious that with this enormous increase in power requirements some means must be provided for generating the power on a scale commensurate with the demand and adequate to the requirements of the future. This means larger stations, and the tendency toward bigger units is strengthened by the growing cost of fuel and labor, as it is a well-established fact that the larger units are more economical in both regards than the smaller ones.

Nevertheless the concentration of very large volumes of power generation in one unit involves certain not inconsiderable difficulties and dangers. Items that would be comparatively small in the central station of moderate size become very big indeed in the giant installations, such as the proposed Stevens super-power central station, and furthermore, like the proverbial carrying of all the eggs in one basket, it involves great dangers in the way that a breakdown of a single big super-power central station would affect the life of the community to a far greater extent than a similar breakdown of only one of several scattered and possibly interconnected units.

It is obvious that on one hand there is a real field for the very large power-generating plants. On the other hand, the design of such plants involves a superlative degree of skill and care both to secure the highest economies in operation possible for this type of construction and to insure the degree of reliability consistent with the vital place which the super-power central station is to play in the life of the community which it serves.

From this point of view the two articles by John A. Stevens, Mem. Am. Soc. M. E., in *Power* (May 25 and June 1, 1920) are worth the most careful consideration.

The basic features of the Stevens plant are the use of a definite large size of unit, namely, 30,000 kw.; the separation of all boiler houses from their turbine rooms by "explosion gaps," the separation of the turbine rooms from each other by explosion walls; and further, the use of a particular type of turbine as the driving unit.

Thirty thousand kilowatts has been selected as the standard size of the unit as being the size within the zone of maximum economy in steam-turbine engineering practice and also as being about the limit of size that can be supplied with four sections of boilers served with one central stack. This size of unit, of which about eight would be used in the station, determines the general arrangement of the station.

The description of the station may be well started with that of the boiler plant. It is proposed to use Stevens-Pratt boilers, of 1716 hp. normal rating, arranged in units of four with one central stack which is from 300 to 350 ft. high in order to discharge the gases and dust at high altitudes. As shown in Fig. 1, the boilers will be installed in practically an independent building with an outdoor passageway between it and the turbine room. The reason for this is safety. Notwithstanding the high degree of skill in the design of large modern boilers, explosions and minor accidents, such as tube failures, are to be expected. To provide for such cases and also to guard against the results of short-circuits in generators an "explosion gap" (so-called) is left between the boiler room and the turbine room, localizing the damage to the plant where the accident occurred.

The same regard for safety has led to the division of each group of turbine rooms themselves by protecting walls which reach to the crane height. With such a wall 25 or 30 ft. high there is some chance for the operators to escape in the case of bursting of steam mains or fittings unless the explosion is very disastrous. Still further, each 60,000-kw. capacity power house should be separated from the next unit of the same size by a space of 20 to 40 ft. in the clear. See Fig. 2.

As regards heating the air which supports the combustion, a very high temperature is not advocated, but only a moderate degree of heat, steam being extracted from high-pressure stages to supply the air heaters.

On the firing floors stands are provided for the main motor-actuated stop valves, which may be controlled electrically from the switch house or from any part of the plant. Also, a master valve at or near the boiler plants, with remote motor control, is desirable, to be used in the event of serious disaster in the turbine room.

For economizers a type is recommended representing a combination of cast-iron sections and steel sections through which the water is pumped in series.

Among features not usual in ordinary plants but suggested for the Stevens super-power station may be mentioned periscopes for observation of the furnaces and for reading the water-gage-glass levels, a remote-control whistle valve, and even a wireless apparatus with aerials connected to the stacks, also searchlights above the elevators for protection of the station in case of disturbances. Telephones are provided at all important points, for example, at or near the boiler-drum manholes, near the fans, etc., so that any accident or defect can be reported instantly. Above the umbrella on the stack and at the base of the umbrella, pipes are provided to wash off the dust that may collect on the plate-glass roof, while underneath this roof a shade is installed on rollers so that on a hot summer day the operating room may be shaded and made comfortable.

As a precaution against damage to the generating units a check valve made of heavy plate is placed at the warm-air discharge to the stoker fan, so that in the event of a minor explosion in the tube area of the boilers the dust and soot will not be blown into the main turbine generator.

No matter how carefully and skillfully a plant of the size of the Stevens super-power central station may be designed or built, from the commercial point of view its ultimate success will be determined by the appropriateness of the selection of the power-generating units. From this point of view it is of interest to note that in the present instance a rather novel turbine arrangement is proposed for use, which the author terms a double-cylinder extraction and low-pressure turbine.

In addition to the power generated by super-stations, considerable amounts of steam have to be used either for district heating wherever there is a field for it or for manufacturing and heating processes. Until recently, however, no turbines were built for operating non-condensing, or against a back pressure of over 60 lb., though in some instances, as, for example, in the rubber industry, considerably higher pressures (80, 90 or even 100 lb.) are desired; and these are what the double-cylinder extraction and low-pressure turbine is intended to supply.

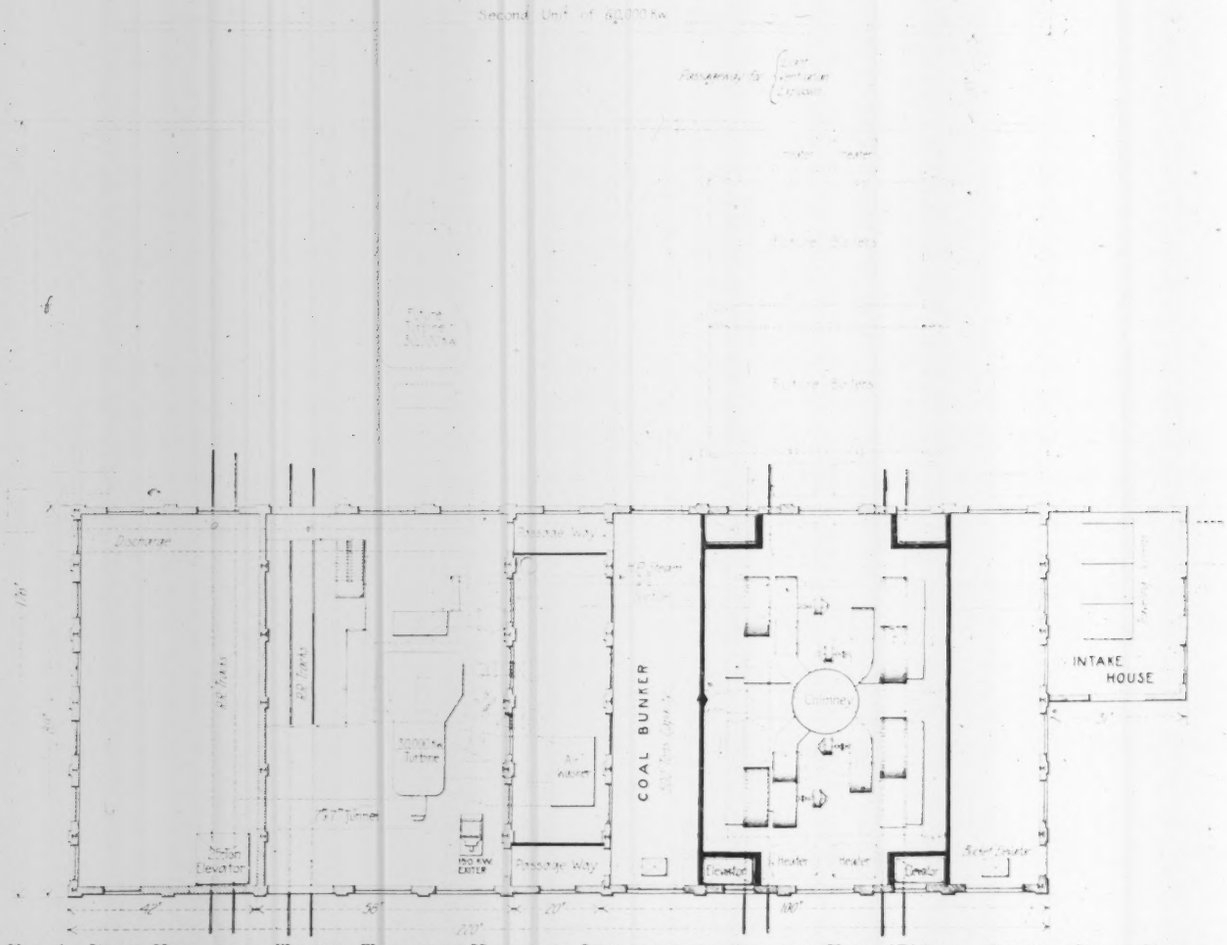


FIG. 1 PLAN VIEW OF A THIRTY THOUSAND-KILOWATT INSTALLATION SHOWING FOUR 1716-HP. STEVENS-PRATT BOILERS AND ONE 30,000-KW. TURBINE. DOTTED LINES INDICATE DUPLICATE INSTALLATION, MAKING A TOTAL OF 60,000 KW. FOR A COMPLETE UNIT

As shown in Fig. 3, such a turbine consists of high-pressure and low-pressure units mounted on one shaft with, say, a 10,000-kw. generator. This machine is said to operate automatically with steam extracted from zero gage to, say, 80 lb. pressure, or from 0 to 244,000 lb. extracted at a predetermined pressure. It will operate entirely condensing with only a slightly reduced economy from that of a standard machine, and it will operate also for any intermediate extraction of steam or generation of power. At the same time large amounts of steam may be admitted to the low-pressure casings in the way of returns from vulcanizing machinery, which should be put through regenerators or separators at 1 to 2 lb. pressure for the precipitation of the acids. The control of this machine is from the sustained or maintained pressure in the steam line to the manufacturing systems. In other words, the machine is controlled from its by-product rather than from its electrical end; but at the same time, if more service is demanded from the electrical end than the proportionate

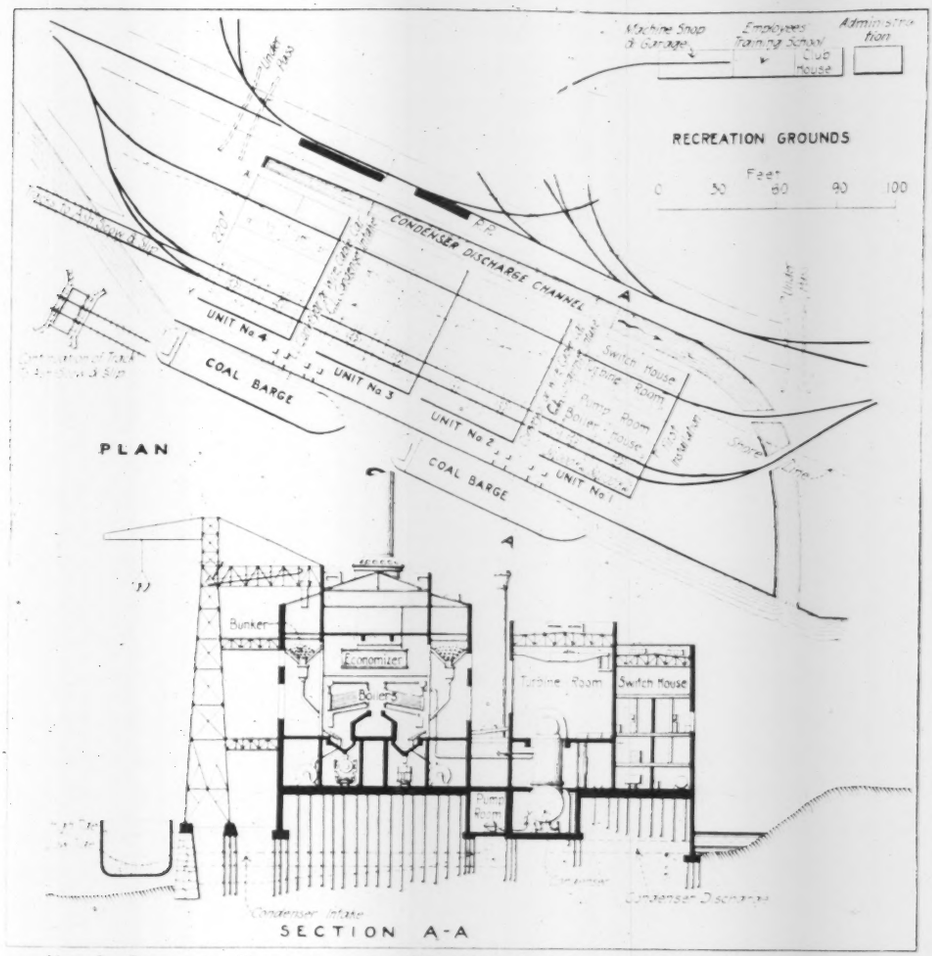


FIG. 2 PLAN AND ELEVATION OF A TWO HUNDRED AND FORTY THOUSAND-KILOWATT SUPER STATION

Note the explosion gaps between each 60,000-kw. unit.

amount of steam passing through to the manufacturing process would admit, the automatic valve mechanism will open to the low-pressure or condensing turbine the necessary amount of steam to follow the electrical demands.

As regards economies, it is stated that a machine of this type

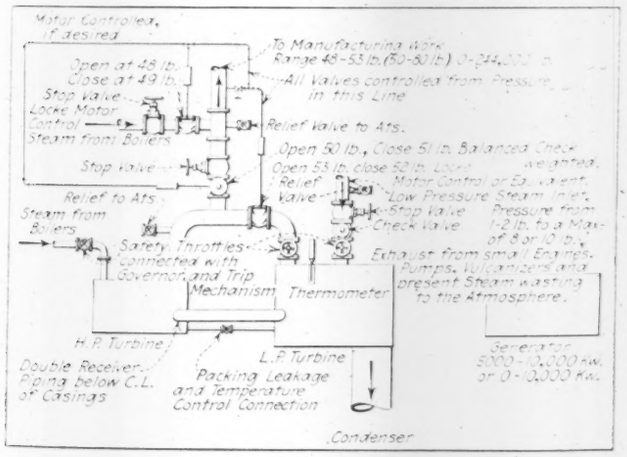

Motor Controller, if desired
To Manufacturing Work
Open at 48 lb.
Close at 49 lb.
Stop Valve
Locks Motor Control
Steam from Boilers
All Valves controlled from Pressure in this Line
Relief Valve to Ats.
Open 50 lb., Close 51 lb. Balanced Check
Stop Valve
Open 53 lb. close 52 lb. Low Relief Valve
Motor Control or Equivalent
Low Pressure Steam Inlet, Pressure from 1-2 lb. to a Max. of 8 or 10 lb.
Relief to Ats.
Steam from Boilers
Stop Valve
Check Valve
Safety Throttles connected with Governor and Trip Mechanism
Thermometer
Exhaust from small Engines, Pumps, Vulcanizers and present Steam wasting to the Atmosphere.
H.P. Turbine
Double Receiver Piping below C.L. of Casings
L.P. Turbine
Packing Leakage and Temperature Control Connection
Generator 5000 - 10,000 Kw. or 0 - 10,000 Kw.
Condenser

FIG. 3 DIAGRAMMATIC SKETCH OF DOUBLE CYLINDER EXTRACTION AND LOW-PRESSURE TURBINE

may be installed to keep the entire output when running non-condensing or part non-condensing and part condensing, at a rate of 7 lb. of steam or less per kilowatt-hour at the generator leads chargeable to power in kilowatts.

For smaller units the author recommends a type of turbine which he terms a power-producing, pressure-reducing turbine (Fig. 4). This turbine is so valved and arranged that it will automatically float on the line and deliver quantities of steam in proportion to the demand, giving a proportionate amount of by-product power. Furthermore, as these turbines are manufactured in small units they may be located at a distance from the boiler plant, which will do away with the necessity of running large and expensive low-pressure mains throughout the plant from the central station.

Summing up, Mr. Stevens states that in his opinion the power plant of the future will be along the basic lines presented in his articles, and he suggests that power contracts be made with the permission to manufacture what power is desired by by-product turbines—that is, by-product to power production—and by such station designs as he has shown in the articles. Continuing, he says:

> Locating these super-power stations in large industrial communities would enormously reduce the amount of coal necessary to handle the power of such communities, for the coal consumed per unit in the super-stations, broadly speaking, is about one-half that of the isolated plant, and by making use of the by-product turbines for manufacturing and heating steam, enormous further reductions in the use of coal are made, to say nothing of a relay power at the customer's plant or at least a part relay to the purchased power.
>
> These large stations require such vast amounts of condensing water that they can be located only on such rivers as the Connecticut or Merrimack, or at shore ports

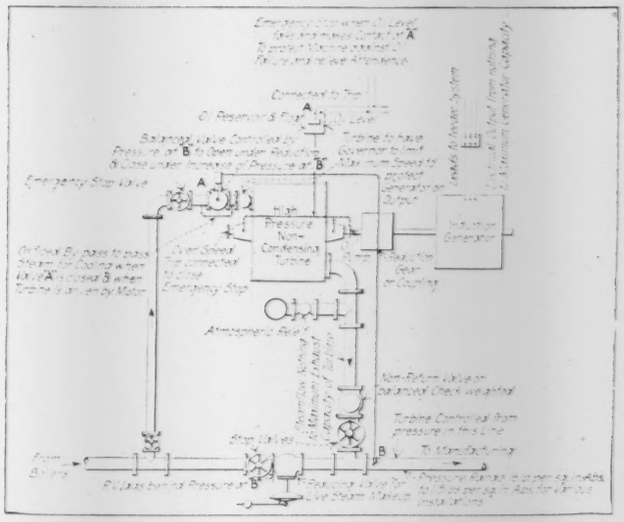


FIG. 4 DIAGRAMMATIC SKETCH OF TURBO-GENERATOR ARRANGED TO OPERATE AS A POWER-PRODUCING, PRESSURE-REDUCING TURBINE

on rivers, lakes or oceans, where the intake canal and discharge canal, or conduit, from the condensers should be 1000 ft. or more apart. Of course, the question of currents, tidal effects and many other conditions enter into this problem, but this statement is made for guidance of designers in planning a station location. Furthermore, it would not be advisable to start any super-station where the ultimate development possible would be less than 100,000 kw. It would be better not to locate in any position where an ultimate development of 240,000 kw. or 300,000 kw. was not possible. This, however, would be controlled

largely by the cost of transmission lines, franchises, money values, and innumerable other conditions that enter into a project of this size.

When otherwise practicable, it will be well so to choose locations for central stations that later full advantage may be taken of economies to be brought about by the recovery and utilization of distillates and other chemical products from coal. This is a matter at present little thought of but likely to be of increasing importance for the future.

To illustrate further what prominent engineers of the country think of the possibilities of the great super-power stations of the

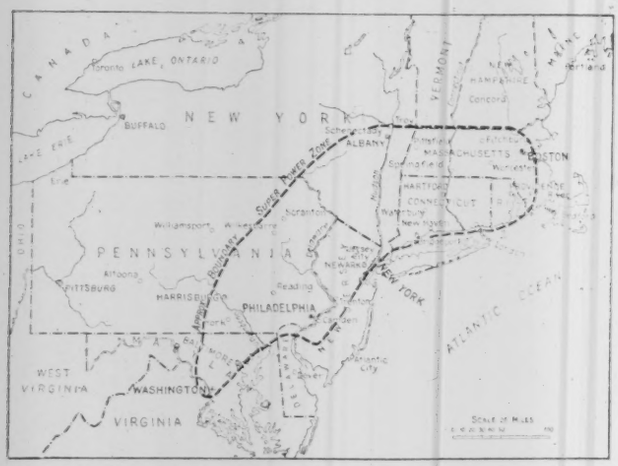


FIG. 5 MAP SHOWING APPROXIMATE SUPER-POWER ZONE

future, Mr. Stevens refers to the super-power plan presented at the Midwinter Convention of the A. I. E. E., New York, February 19, 1920. The zone embraced by this plan (see Fig 5) comprises the area between Boston and Washington and extends inland from the coast 100 to 150 miles. The transmission lines from the hard and soft coal fields, Niagara Falls, Cedar Rapids on the St. Lawrence, and from the Maine hydroelectric plants which Mr. Stevens suggests are shown in Fig. 6. He says:

> From investigations and research I have found that there is a 300,000-kw. load, not including the steam-railroad electrification, within a radius of fifty miles from Newburyport or Beverly, Mass., which could be tied in with the great water-power developments at Manchester, N. H., Lowell and Lawrence, Mass., and with the great development and proposed developments of the Edison Company, of Boston, Mass., the conservation in this power zone alone amounts to about 500,000 long tons of coal per year, conservatively speaking, with all the attendant advantages in the conservation of coal, money and men. The project considers the use of the river banks and railroad rights-of-way for transmission lines, and placing a station of that kind in the northeastern range of the proposed super-power zone illustrated by Fig. 5 would reinforce in a splendid manner the loop transmission line suggested.
>
> Further, there is a vast amount of coal in Nova Scotia which, if used as pulverized fuel, would make two methods of shipment to this point by water—Nova Scotia coal and coal from the Virginia fields. This would greatly relieve the congested freight situation.
>
> A cross-tie in this loop in New England and somewhat paralleling the Connecticut River and its hydroelectric and large steam developments is suggested. This would further substantiate and augment the eastern part of the super-power zone loop in New England and would also further relay the great power demands of New York City and vicinity. There are other untold resources in New England for such a project as has been outlined herein.
>
> The time will come when no company or individual will be allowed to operate any plant at a thermal efficiency of less than a predetermined percentage; neither will any company be allowed to operate any turbines or equivalent machinery condensing when they could be operated non-condensing and the exhaust steam used in heating and

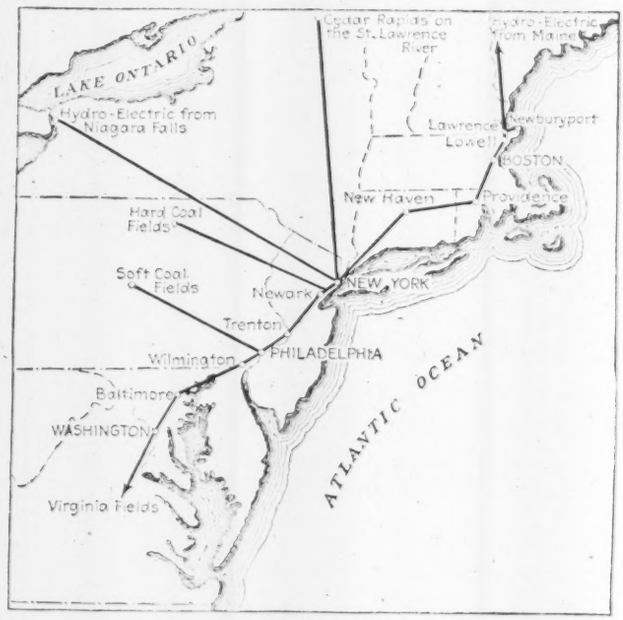


FIG. 6 SUGGESTED POWER-TRANSMISSION LINES FOR SUPER-POWER ZONE

manufacturing, or when purchased power from a large super-station can be advantageously made available. In other words, as coal and oil, in fact, all known fuels, are non-renewable, natural resources, the general public will be forced to use the utmost care in their consumption. (*Power*, vol. 51, no. 21, May 25, 1920, pp. 832-836, 3 figs.; and no. 22, June 1, pp. 879-884, 11 figs.)

General Electric Design of a Super-Power Station

THE high cost of fuel today and the prospect that it may go still higher in the future have given a powerful impetus toward the development of central-station design in which coal will be used with the greatest economy.

This tendency has been materially assisted by the rapidly growing demand for power. Both of these factors have created a situation where, in many instances, it becomes possible to build power plants of practically any size that will permit their economical operation, the question of getting rid of superfluous power being practically absent through the fact that there is no superfluous power available today and very little prospect of there being any in the near future.

The design described by H. Goodwin, Jr., and A. R. Smith was developed for a particular condition where some of the fundamental considerations were high fuel cost, moderately good load factor, extreme river floods and high-voltage underground distribution. It contains, however, features of great interest and capable of general application. Some of the apparatus shown, particularly boilers, economizers and preheaters, are only proposed designs.

The idea underlying the entire design of the proposed super-power station is that great economy can be obtained from large-capacity generating units operating at high steam pressure, especially when a number of these are located in one station.

In the present instance, a steam pressure of 350 lb. and superheat of 350 deg. fahr. are proposed to be used, which means that both the boilers and the turbines have to be adapted to comparatively new conditions.

The boilers (Figs. 1 and 2) will have a rating of some 1600 hp., or 16,000 sq. ft. of heating surface, and will have the two banks of tubes separated with the superheater in between. The reasons for this arrangement are, first, to permit using a two-pass boiler and still keep the economizers on the main floor, which means a greater number of tubes in height; and second, to get a high amount of superheat without an excessive amount of superheater surface.

The high pressures and superheats employed make it necessary to simplify the steam piping as much as possible so as to make the entire piping system more flexible and avoid accidents. Hence there are no steam headers in the general sense of the word, but there is a transfer header for equalizing pressures and transferring steam between boiler rooms. The steam piping is also materially simplified by the fact that there are no steam-driven auxiliaries except the few house or auxiliary turbines, of which more will be said later.

The economizers will be of wrought-iron tube construction with headers inclined with relation to the tubes. They will be cleaned with steam soot blowers, and it is anticipated that there will be no moist soot deposit, because the water entering the economizers will first be heated to 150 deg. or 160 deg. with exhaust steam, this bringing the temperature well above the dewpoint of the gases.

The flow of water in both the vertical tubes and the headers is of the thermo-siphon type, with the flow of the gases and water in the economizers in countercurrent.

The air going to the boilers comes through a tunnel (Figs. 1 and 2) from the turbo-generators, which means that it is preheated. In addition to this, air may pass through heating tubes in preheaters divided into two units per boiler, the arrangement being such that the boilers nearest to the turbine room will burn the heated air discharged from the generators, whereas the boilers at the far end will burn the air from outside. In this connection a remark is made to the effect that it is believed that preheaters are perfectly practicable for use in stationary plants and can be made to show a good return on the investment if the cost of coal is at all high.

The use of economizers and preheaters makes induced draft unavoidable in view of the increased draft losses and the low temperature of gas entering the stacks. The draft fans might be of the ordinary belt type, or possibly of the multi-vane type, as the temperature is low and the pressure comparatively high. The induction type of stack employing high-pressure blowers may be substituted and, in general, provision should be made for the case of failure of fans.

The very high steam temperature involved in the present design makes it practically impossible to use any small steam-driven auxiliaries, such as boiler-feed pumps, etc. On the other hand, the auxiliaries, especially feedwater pumps, should be of the great possible reliability, which means that it would not be advisable to drive them electrically from the main buses. The installation of low-pressure boilers to operate the boiler-feed pumps would not be advisable either.

In order to meet these conditions it has been decided to use one 2500-kw. auxiliary or house turbine for each pair of main turbines. Such a unit can be very well adapted to the steam conditions contemplated, and will have sufficient capacity to supply all auxiliaries through a separate busbar.

As regards condensers, the main condensers will be of standard design. The house turbines will each be provided with a low jet condenser which will normally produce about 15 in. of vacuum. The circulating water for this condenser is the condensate from the main units, in addition to which some of this water may be recirculated.

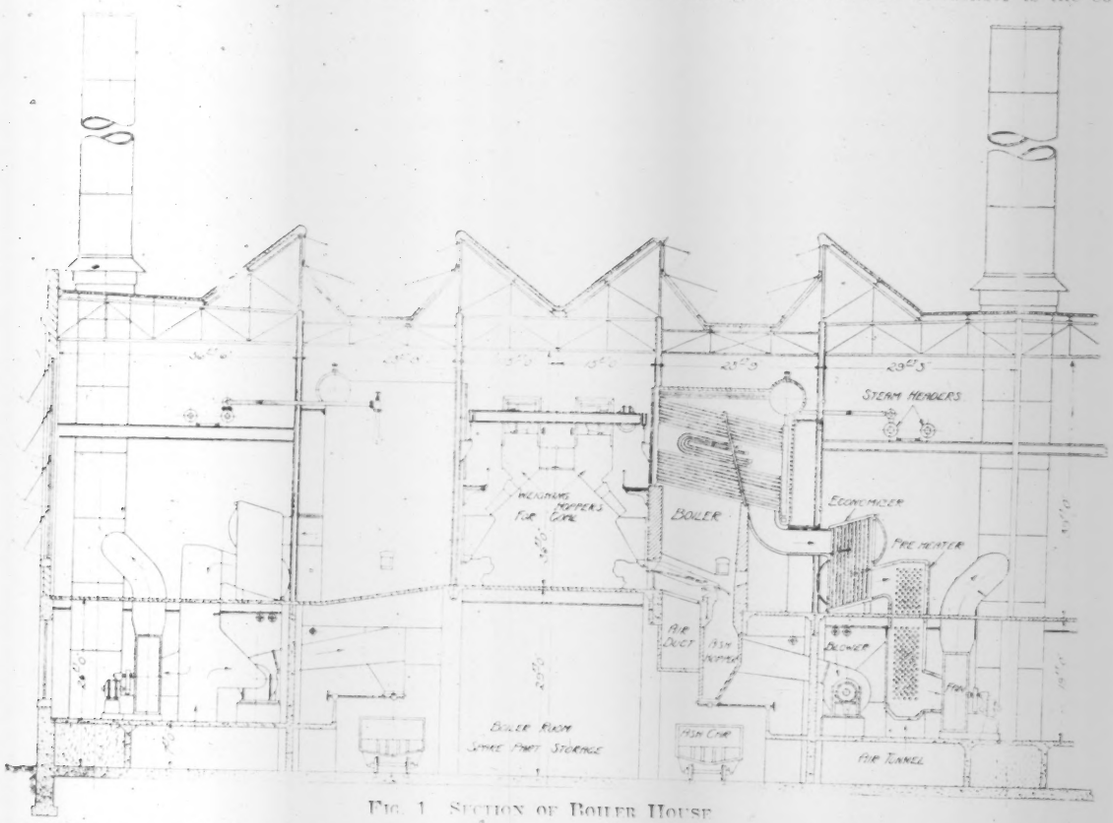


FIG. 1 SECTION OF BOILER HOUSE

In a plant of the proposed size, the question of coal- and ash-handling equipment becomes of great importance. As regards the latter, it is proposed to dispense with all kinds of ash-conveyors and instead provide under each boiler ash hoppers of such capacity as to contain 12 or 24 hours' storage, so that ashes need to be removed only once or twice during the day, the ash hoppers emptying directly into standard railroad cars.

The coal-handling equipment has been designed so as to have the bulk of the coal unloaded from barges by means of traveling crane towers at the dock and transported by two belt conveyors directly to the four receiving hoppers and crushers. From the receiving hopper the coal is delivered directly to the outside storage or through a crusher and skip hoist to the overhead outside beams.

The duplicate belt conveyors provide a large coal-handling capacity when needed, and also act as a reserve in case one conveyor should break down. All belts are dead-ended and there are no traveling trippers.

The intention is that one operator located in a control cab

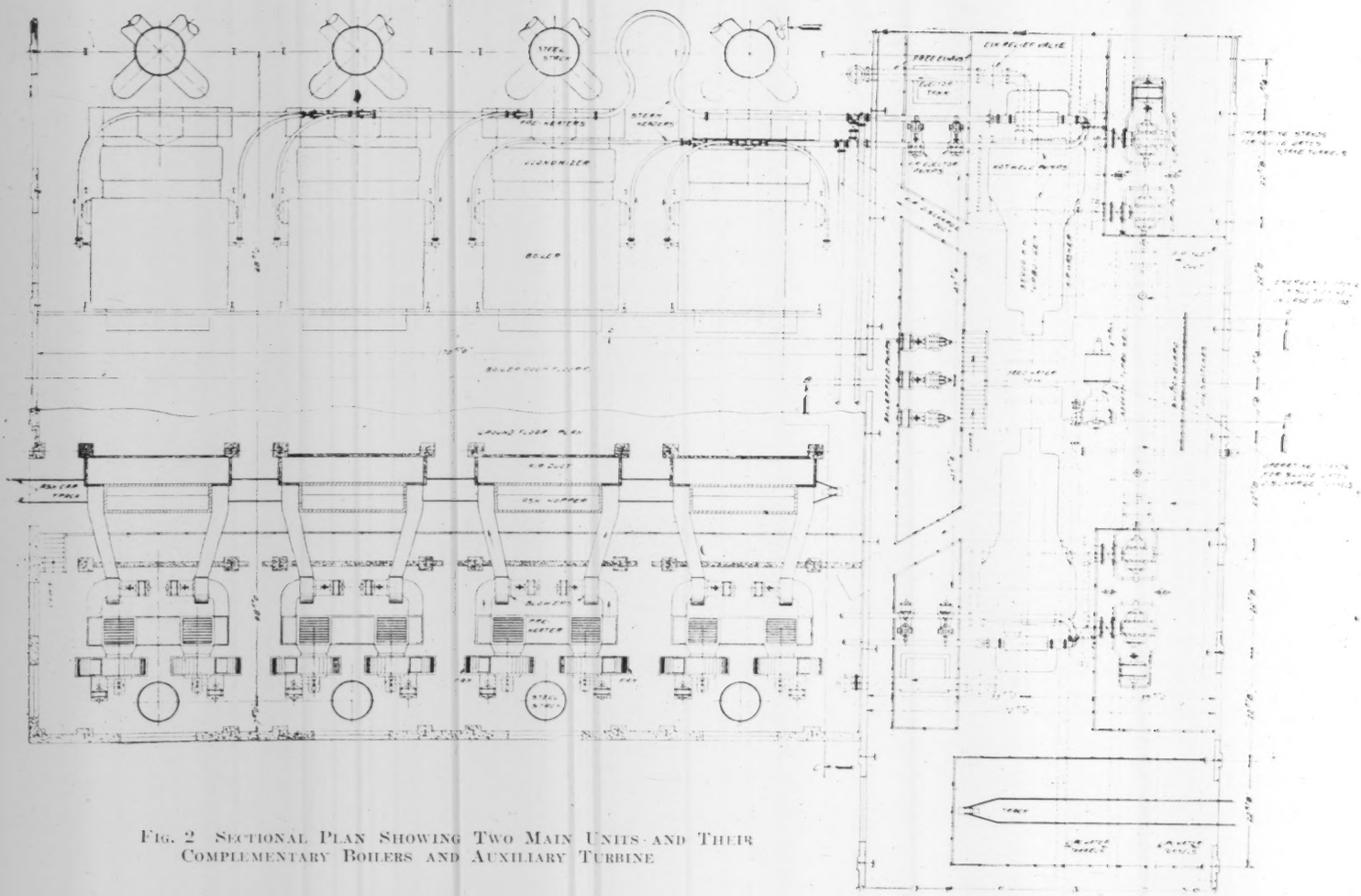


FIG. 2 SECTIONAL PLAN SHOWING TWO MAIN UNITS AND THEIR COMPLEMENTARY BOILERS AND AUXILIARY TURBINE

above each receiving hopper will operate the revolving gantry crane, the crusher, the skip hoist, etc. Another operator will be located on each electrically operated larry to transport and weigh the coal from the overhead bins to each boiler. The emergency coal storage handled by the locomotive traveling crane will be operated only when the excess coal is being stored or reclaimed.

It is proposed that there be one spare larry which can be readily run into any one of the four firing aisles to replace any defective larry. It will be observed that the revolving gantry crane reclaims the coal from the circular storage without moving the bridge; thus this method is very rapid when reclaiming coal, although in distributing the coal the bridge will have to be moved slightly from time to time, but to minimize this movement outside shoots are shown on the four sides of each receiving hopper tower. The revolving gantry cranes overlap so that coal can be transferred from one pile to another, and, furthermore, the design shown can be partially built and extended from time to time without interfering with operation or without changing existing structures.

As yet no data are presented as to the character of the main driving units. It is stated, however, that the total generating power will be 245,000 kw., 300,000 kva. capacity on 66,000-volt distribution. (*General Electric Review*, vol. 23, no. 5, May 1920, pp. 355-418, 15 figs)

Economics of Power Generation

THE growing cost of fuel and labor forces power-generating stations to keep much closer track than ever before of every item of their expenditures, with the result that some rather unsuspected relations have been discovered.

Thus, a recent analysis of the log-sheet records of a typical electric generating station in England showed that the coal consumption might be regarded as being made up of two separate items, namely, a constant quantity per shift, which in this instance was 14,560 lb., and an additional amount for every kilowatt-hour produced—in this case 2.2068 lb.

This held good not only for heavy enough loads but also for the Sunday and early-morning loads, when the station was running only at a small percentage of capacity.

The corresponding investigation with respect to the water consumption of the station showed that this also might be regarded in a similar way, namely, as a constant quantity of 60,000 lb. of water per shift plus an additional amount of 14.37 lb. for every kilowatt-hour generated, this covering, however, only the amount of water delivered to the boilers.

These results may be expressed in the form of equations—

$$C = 14{,}560 + 2.2068\,K \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

$$W = 60{,}000 + 14.37\,K \quad \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

where C represents the total number of pounds of coal burned per shift, W the number of pounds of water evaporated per shift, and K the output per shift expressed in kilowatt-hours. This permits expressing either the coal consumption in terms of water evaporation or vice versa as shown by the following equations:

$$C = 5346 + 0.1536\,W \quad \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

$$W = 6.512\,C - 34{,}810 \quad \ldots\ldots\ldots\ldots\ldots\ldots [4]$$

From Equation [1] it is evident that the greater the output the less important becomes the constant quantity of 14,560 lb.

of coal, the station tending more and more nearly to a coal consumption of 2.2068 lb. per kilowatt-hour as the load increases. This is the limiting value of coal consumption for the particular plant. As is the case with all limits, it can never be actually attained, but will be approached as the output becomes greater. The same applies to the question of steam consumption.

These equations would further indicate that within the capacity of the plant any additional load given to the station may be considered to be generated for a net expenditure of 2.2068 lb. of coal and 14.37 lb. of water per kilowatt-hour, although the average coal and water consumption, if calculated by usual methods, would be considerably greater. This determines the cost of service on extra loads, which do not necessitate any increase in wages, capital charges, or items of expenditure, except coal and water.

Equation [4] is of interest as it shows that the water evaporated per shift is 34,810 lb. less than it would be if every pound of coal evaporated 6.512 lb. of water. Obviously, the greater the output the less important becomes the constant, which has to be deducted from the weight of water evaporated and in the limit 6.512 lb. would be turned into steam for every pound of coal burned. The low value of evaporation is in this instance ascribed "entirely to the nature of the material which is sold as coal nowadays," in the words of the author, which show that the British have to contend with pretty much the same conditions we have in this country.

An interesting application of the above equation is made to the measurement of the so-called stand-by losses, which is done in the following manner:

Referring to Equation [1], it will be seen that in the particular station under consideration, if no power at all were generated for a shift, there would nevertheless be required 14,560 lb. of coal to be burnt during this time to keep the station in a condition to take the load when required. The purpose of this amount of coal is to make good all the heat which is lost in the plant, whether by radiation, chimney losses, or condensation, and irrespective of whether the losses are in the engine room or the boiler room. Turning now to Equation [3], we see that if no water were to be evaporated during the shift, i. e., if the boiler-feed valves and junction valves were shut and only sufficient fuel were burnt to maintain the boiler house in a state to take up the load when called upon, the coal consumption would be 5346 lb. per shift. Hence this amount may be considered as equivalent to the boiler room losses, while the difference between 14,560 and 5346, which is 9214 lb., may equally be regarded as representing the engine-room losses. The writer is aware that this method of reasoning is open to criticism, but, from a considerable experience of power-plant economics, he is inclined to believe that the deductions are of practical value and possess a very large measure of truth.

The constant water loss of 60,000 lb. per shift, given in Equation [2], may seem high, but it is well in line with corresponding figures from other power stations. It must be remembered that the no-load condition in the engine room implies that the output has fallen to zero, but not that the plant is shut down. Now when it is realized that even a small turbine may have a no-load consumption with ordinary conditions of steam and vacuum, of something like 5000 lb. of steam per hour, or 40,000 lb. per shift, the total stand-by loss of 60,000 lb. of steam per shift does not appear excessive. The balance of 20,000 lb. per shift has to provide for running the turbine auxiliaries, the boiler-feed pumps, and the stoker engines as well as for leakage and condensation in the whole system. The stand-by steam has obviously to be generated by the stand-by coal, so that the evaporation at no load is found to be equal to 4.12 lb. of steam per pound of coal. If, however, we subtract the 5346 lb. of coal required to make good the boiler-room losses as deduced above, the evaporation works out to 6.512 lb. of water per pound of coal, which is what would be expected from Equation [4]. (Robt. H. Parsons, in *The Times Engineering Supplement*, vol. 16, no. 548, June 1920, p. 190).

Report of Committee on Prime Movers of the National Electric Light Association

THE following excerpts have been made from the report of the Committee on Prime Movers of the National Electric Light Association, Technical and Hydro-Electric Section, which was presented at the forty-third convention of that society, May 18-22, 1920. The report is very much in detail, comprising 130 large-size pages, and covers the following subjects, considered in the main with respect to recent developments and current practice: Steam Turbines, Condensers, Boilers and Superheaters, Economizers, Grates and Stokers, Burning Lignite, Pulverized Fuel, Coal By-Products, Fuel Oil, Coal and Ash Handling, Power-Station Auxiliaries, Boiler- and Turbine-Room Instruments, Ventilation of Station Buildings, Higher Steam Pressures, Oil Engines, Hydraulic Prime Movers, and Hydraulic Operation and Combined Operation of Hydraulic and Steam Plants. Considerable space is devoted to reports from manufacturers on improvements or changes in design in steam boilers, condensers, grates, stokers, etc. In the quotations which follow, however, attention is mainly given to new developments of a broader nature and to operating features. These quotations, also, relate only to steam plants using coal as fuel.

Steam-Turbine Development

A record of the units which have been manufactured since the last report indicate that 30,000 kw., 1,800 r.p.m., 60 cycles, and 35,000 kw., 1,500 r.p.m., 25 cycles, can be considered for the present as the maximum standard sizes of single-shaft, single-barrel units for large installations.

During the past year a considerable amount of information has been obtained from the operation of these large-sized units as well as from some of the smaller machines, and a period of adjustment and improvement in both design and construction, following the experience which has been gained, would seem to be imperative if these large-sized machines are to be brought to a requisite degree of reliability and operating efficiency.

The records of operation of single-shaft units have not by any means been satisfactory. Since the last report there have been several additional wheel failures which have occurred to units of this type and on sizes ranging from 5000 to 30,000 kw. capacity.

The General Electric Company has made a number of marked changes in the design of its large-sized turbines, the principal changes being the stiffening of the center bearing and modifications in the design of turbine disks, buckets, diaphragms and packing.

The changes in the turbine disks consists of a thickening of the disk in an attempt to reduce the possibility of injurious vibration; elimination of the weight-balancing holes, and the change in the number and location of steam-equalizing holes so as to move them well in from the rim; and changing from an even number to an odd number of holes with rounded and polished edges at the wheel surface.

The changes made in the buckets, particularly in the last stages, consist of the addition of a reinforced section, carrying it nearly to the center of the bucket so as to stiffen the construction materially. In addition, the very long buckets are reinforced by the use of a bracing strip, in order to minimize any vibration which might occur.

The changes to the diaphragms consist of replacing some of the cast-iron sections by cast-steel construction where stresses indicate this to be necessary. Additional clearance space around the diaphragm is also provided with the idea of allowing for the removal of a large part of the condensed water, which has

contributed to serious erosion of the blading in certain stages. A radical departure has been made in the type of diaphragm packing. The new type differs from the earlier construction in that the stationary, inwardly projecting short teeth of the labyrinth have been changed to much longer teeth which are mounted on the revolving element. It is claimed that this improvement makes it practically impossible, when properly installed, for any rubbing to distort the shaft due to the generation of heat at the point of contact.

An analysis of the cause of the serious wheel failures during the past year has resulted in the accumulation of sufficient data to indicate that the trouble has been due in the past to a vibration of the wheel structure. This vibration, which has been described as a fluttering of the web of the wheels, in combination with the high working stresses of the material, gives rise to the formation of fatigue cracks. These cracks, which occur not only in the wheel but also in the bucket, when allowed to continue, result in a complete rupture. This action was accentuated in the disks where sharp tool marks or rough surfaces are present, or where holes for weight- or steam-balancing purposes are drilled in the wheel. Considerable investigation is still necessary, however, in connection with the subject of vibration of wheels before the full facts can be known and a proper design be forthcoming that will eliminate any danger from this source of trouble.

No marked changes have been introduced during the past year by the Westinghouse Electric & Manufacturing Company in the design of its single-cylinder units up to 30,000 kw. rating, although a number of minor improvements have been made. To meet the demand for larger capacities than 30,000 kw., the company has standardized on combinations of single-cylinder units of 20,000 to 22,000 kw. maximum rating in tandem, cross-compound and triple-cylinder arrangements.

While the combination of compound turbo-generators seems to be increasing in favor, and while test results indicate a higher thermal efficiency for such a combination as compared with single units of the same aggregate capacity, sufficient data are not at hand to show conclusively whether the practical operation of units bears out the theoretical advantages which are claimed.

Balancing Turbine Rotors

While it has been standard practice for years in large manufacturing companies to balance statically all high-speed rotating parts, it is only recently that equipment has been developed that will readily permit of correct dynamic balancing of rotating elements.

One type of machine, the Carwen static-dynamic-balancing machine, has proved very effective in the balancing of moderate-size rotating elements. The principle of operation of this machine depends upon the creation of an artificial unbalance in some of its own moving parts, which exactly counteracts the unbalance of the body to be tested. When this artificial couple or unbalance becomes the exact counterpart of the unbalance in the body being tested, the whole unit ceases to vibrate and the quantities of the unbalance are indicated on suitable dials located on the machine.

The Akimoff combined static and dynamic balancing machine, although built along somewhat different lines, has also a bedplate hinged in such a manner as to vibrate in the two planes. No compensating couple is used in this machine. Instead, a balancing clamp is attached to one end of the object to be balanced and rotates with it. The position of the clamp and the location of a sliding weight attached to the clamp are changed until the resultant of the unbalanced force is neutralized and the vibration reduced to zero.

Another device which has recently been designed and built for measuring the amplitude of the vibration of machines while in operation—called the "Vibroscope"—has given very satisfactory results. In this device the frame or vibrating part of the instrument is so arranged that it may be conveniently attached to the machine whose amplitude of vibration is to be determined. The upper leg of the frame is slightly inclined, and has attached to it by a thin, flexible spring hinge a heavy, flat-plate pendulum supporting a micrometer microscope as its outer end. This pendulum plate has a very slow period and becomes the "steady point" of the combination. Directly beneath the microscope at the end of the horizontal part of the frame is a narrow slit illuminated by an electric light. By looking through the microscope with the instrument at rest, the width of the slot is adjusted to, say, five divisions on the illuminated scale; then with the machine running, any apparent increase in the width of the light slot is due to vibration. The amplitude of the vibration of the machine under test can be directly determined by proper calibration of this amplitude with relation to the fundamental amplitude of vibration of the vibroscope.

In connection with vibration and the fatigue of metals the following statement has been obtained from Prof. C. A. Adams, Chairman of the Engineering Division, National Research Council:

> A very comprehensive research into the fatigue of metals is being conducted at the University of Illinois under the auspices of the Engineering Division, National Research Council, and under the direct supervision of Prof. H. F. Moore, with the assistance of an advisory committee of the Engineering Division.
>
> The amount appropriated by the Engineering Foundation Board for this research is $15,000 per year for two years. In addition to this, the University of Illinois contributes, in the services of Professor Moore and other overhead expenses, the equivalent of at least $6,000 per year.
>
> The chief object of the research is to establish as far as possible such fundamental laws of the fatigue of metals as will make possible the intelligent design of apparatus and structures which are likely to be subjected to alternating stresses.
>
> The investigation will determine whether the stressing of the metal during vibration is above or below the elastic limit, and if below, how much time may be expected to elapse before rupture occurs.

It is expected that this experimental work by the National Research Council will furnish a great deal of valuable data in connection with the design of turbine blading and disks.

Gear-Driven Turbine Units—Erosion of Gears

The record of performances of small gear-driven units as experienced by operating companies has, in a number of instances, been far from satisfactory, the troubles being due in many cases to the abnormally excessive wear on the reduction gears.

An analysis of other gear troubles experienced indicates a number of reasons for their occurrence which summarize as follows: In some cases the oiling systems are incorrectly designed, or an improper grade of lubricating oil is used. Other cases of gear troubles are traceable to excessive or uneven tooth pressure, end play and poor meshing. The remedy for this class of trouble is purely of a mechanical character and readily corrected if detected in time. Mention has also been made of cases where the wear and tear on the gears has been aggravated by unbalanced rotating parts, or by foundations which have not been sufficiently rigid to maintain properly the correct alignment of the gear-teeth faces.

The manner and point of application of the oil to the gear are of prime importance. It is evident, therefore, that the oil must be applied at a point on the gear where it will most effectively reduce the friction to a minimum. The oil should be of a viscosity best adapted for the class of work intended, used in sufficient quantity, and applied to the entering side of the gear in a continuous film. Excessive oil does not improve gear lubrication and is likely in some cases to reduce the efficiency of certain types and design of gears, with a consequent increase of temperature. Sufficient space, however, should be provided in the gear casing so that when the oil has reached the maximum safe operating temperature it may be allowed to cool, rest and settle, to permit liberating as much as possible of the air or water globules it has collected during the period of work under actual churning conditions. Maximum oil temperatures allowable in best operating practice vary from 110 to 160 deg., according to the grade of oil and class of gear.

Examination of a number of gears from units which have been in operation over various periods of time, which were operated under proper conditions of lubrication, and where the alignment was satisfactorily maintained, shows a decided pitting below the pitch line in the gear and slightly above in the pinion, this line

being the point at which the maximum tooth pressure occurs. A number of interesting experiments have been made during the last year, which seem to indicate that a considerable amount of gear erosion is due to causes other than those directly resulting from mechanical action.

Through the courtesy of Mr. S. K. French, of the American International Shipbuilding Corporation, a considerable amount of interesting information has been secured, based on the results which he has obtained in the investigation of gear operation in connection with gear drive for ship propulsion. It would appear that the pitting is due to the action of the oxygen content of the air in the oil film, which is entrapped under high pressure between the gear-teeth faces.

When the gear teeth come in contact with each other, the oil film on the gear is submitted to an action similar to that of a hammer stroke, more sliding than direct. The globules of air, which have been churned with the oil, are entrapped in this oil film, and are likewise submitted to a pressure sufficient to generate enough heat to cause an oxidization or burning of the metal in the tooth face. A number of experiments have already been carried out following this assumption. These experiments consisted in, first, adding a large quantity of oxygen to the gear casing; second, in supplying the gear casing with a mixture of nitrogen and CO_2. In the first series of tests, excessive pitting was noticed within a few hours' running, while in the operation of the gears in a mixture of nitrogen and CO_2, or where only a small amount of oxygen—approximately six per cent or less—was left, continuous operation over a long period of time indicated absolutely no pitting. Although the results cannot be regarded as conclusive, there is reason to believe that valuable information will soon be forthcoming, aiding in the solution of the problem of the more successful operation of gears. It is well known that certain classes of oils have a greater affinity for air and water than others of a different base or grade. These oils, after being churned with air or water and then allowed to settle, free themselves very slowly. It is evident that if this is true, the settling action, the size of the gear casings, the capacity of the oiling system, and the grade of lubricating oil must be given most careful consideration.

Higher Steam Pressures

Boiler manufacturers seem to feel certain that steam generators can be produced which will work satisfactorily at pressures as high as 1000 lb., but they all recognize the fact that such steam generators must be designed along lines different from those now in use. Present designs of water-tube boilers are variously estimated as adaptable to pressures of from 300 to 450 or even 500 lb.

Turbine builders express themselves as capable of producing turbines for any pressures for which boilers can be developed, but they place an upper limit on temperature. This limit is variously set at from 650 to about 800 deg. fahr.

Manufacturers of valves and fittings believe that they can produce such materials for steam pressures up to 1000 lb., provided the maximum temperature is limited to between 700 and 800 deg. fahr.

The majority of the manufacturers of power-plant equipment and the better known power-plant designers all seem to feel the desirability of using higher pressures as a means of continuing the development toward higher thermal efficiency which has been so rapid during the past two decades.

Power-plant executives will welcome anything which will assist in counteracting the effect of the ever-rising prices of fuel and labor.

This may all be summarized by saying that such information as is available indicates the possibility of building plants to operate at pressures not in excess of 400 to 450 lb. at temperatures not in excess of 700 to 800 deg. fahr, if it can be shown that the thermal gain actually realizable is sufficient to more than offset the increased first cost and probably increased maintenance. The boilers used would probably be heavy versions of present-day designs and not necessarily the most economical for such pressures.

However, it is not to be assumed from this summary that such an advance can be made in any easy fashion. Almost every piece of apparatus will require redesign and the highest type of engineering skill will be required to prevent costly failures.

In this connection attention is called to the fact that the A.S.M.E. standardization of flanges extends to a maximum of 250 lb. only.

At the present time 300 lb. with a total temperature of from 650 to 700 deg. fahr. may probably be taken as a conservative limit, and even under such conditions a high degree of operating skill is required even when the best obtainable apparatus is installed. Smaller plants which cannot ordinarily afford the most skilful operators will probably find the economic balance at a pressure in the neighborhood of 200 to 250 lb. and a total temperature not in excess of 600 deg. fahr. for some time to come.

As a result of these visits it can be stated that real operating difficulties have been experienced with valves and fittings operating at pressures in the neighborhood of 300 lb.

Welded joints in the steam line, such as were described in a previous report, are satisfactory so long as the line remains in continuous service. If cut out of service frequently, leaks develop at a rapid rate.

On large valve bodies by-pass valves and bonnet joints have given more trouble than usual.

Leaks developing under this pressure must be repaired at once because cutting of the metal occurs very rapidly. Attention is called to the fact that this corresponds to the experience of the builders of high-pressure steam automobiles, who found it extremely difficult to construct a tight throttle valve because of the rapidity with which the metal was cut away by the steam.

Blow-off valves have given more than the usual amount of trouble because of leakage, and similar statements can be made with respect to water column blow-off valves, valves on drips, and other small valves.

Influence of Microstructure of Metal on the Resistance of Condenser Tubes to Corrosion

The experience of the Southern California Edison Company with condenser tubes lasting over a period of eight and a half years at the Long Beach steam plant, has indicated that the microstructure of the metal has a great influence upon the resistance of the tube to corrosion.

As an illustration of the difference in tubes operating under similar conditions, there are three condenser units at Long Beach: No. 1 on a 12,000-kw., No. 2 on a 15,000-kw., and No. 3 on a 20,000-kw. turbine; all vertical machines, all taking water from the same tunnel and operating under practically the same temperatures.

In No. 1 condenser 21 tubes failed during 725 hours of operation; in No. 2 condenser 13 tubes during 2156 hours; and in No. 3 condenser 1892 tubes during 6232 hours. Thus there failed respectively 29, 6, and 336 tubes for 1000 hours of operation. The No. 3 tubes were found to be very coarsely crystalline, whereas both No. 1 and No. 2 tubes were of fine grain. Replacing the coarse-grained tubes with others of a fine structure cured the trouble.

Such microphotographic study as it was possible to make indicated that dezincification occurred round the crystal boundaries or possibly in the matrix surrounding the crystals. When the crystalline structure is coarse there is more tendency to local pitting; with fine-grained tubes the dezincification proceeds uniformly until the tube finally breaks from brittleness.

As a precaution against electrolysis the tube sheet was bonded to the condenser head and shell.

At times there was experienced trouble with erosion of the ends of the tubes which the water enters, this erosion extending in about three inches, probably until a steady condition of flow takes place. It has always been associated with dredging operations near the water intake and is attributable to fine sand in suspension. All the tubes are of Admiralty mixture, not tinned.

It would be of great advantage to condenser-tube users if some simple physical test could be applied to all tubes to in-

dicate their fitness as regards microstructure, as actual microscopic study takes too long and is too expensive.

Pulverized Fuel

The past year has witnessed an increased number of powdered-coal-burning plants installed and a quite rapidly growing interest on the part of engineers in this development. The handling of powdered coal in large quantities has been successfully carried on in steel plants and cement mills, the coal being transmitted for a distance as great as 2000 ft. from the powdering plant. On the other hand, several companies are now placing on the market unit pulverizing equipments, one or two units being installed for each boiler. So far as the mechanical details are concerned, either the centralized powdering plant or the unit system seems to be highly satisfactory.

One of the earliest and largest plants with pulverized-coal equipment, both in combined capacity and capacity of individual boilers, is that built by Stone & Webster for the Western Avenue steam-heating station of the Puget Sound Traction, Light & Power Company at Seattle, Washington.

The Seattle installation was the outcome of extensive experiments, and the equipment is especially adapted for handling lignite washery sludge from a dump of about 200,000 tons at the Renton Mine, just outside of that city.

The boiler plant comprises ten boilers of an aggregate rated capacity of 4100 hp. The preparation plant includes: Raw-coal bunkers, roll-type crusher, crushed-coal bunker, rotary driers, drier-coal bunker, pulverizing mills and pulverized-coal bunkers, with the necessary conveying and transferring equipment. From the pulverized-coal bunkers the fuel is delivered by screw feeders to the burners. As the driers are fired with pulverized coal, and the entire preparation equipment is operated under a slight vacuum, the installation is practically dustless throughout.

The sludge burned reaches the plant carrying about 25 per cent moisture, with a heating value of 7500 B.t.u.; ash on the dry basis, 20 to 25 per cent. With this fuel boilers are operated on a steam-heating load at 150 per cent to 175 per cent rated capacity.

There are other installations in various parts of the country operating on somewhat less severe fuel conditions serving boiler plants of capacities around 2500 hp. which are also showing very satisfactory performance. Among these may be mentioned the 2340-hp. installation of The Milwaukee Electric Railway & Light Company at Milwaukee, Wisconsin, burning a mixture of Eastern Kentucky and Youghiogheny slack; the 1875 hp. of the British Columbia Sugar Refinery Company at Vancouver, B. C., burning the Nanaimo slack from Vancouver Island; the 2840 hp. of Morris & Company at Oklahoma City, Oklahoma, burning bituminous slack from the Arkansas-Oklahoma fields; and the 1800 hp. of the M. A. Hanna Coal Company at Lytle, Pa., burning anthracite slack.

Speaking broadly, however, the boiler installations, as now in operation, were not designed primarily for pulverized coal, but are adaptations of settings originally constructed for use with some other form of fuel and, on that account, are necessarily subject to many limitations inherent in previously existing local conditions. In spite of this handicap, the commercial practicability of pulverized coal as a boiler fuel has been thoroughly demonstrated. A number of installations are now under construction, designed throughout for the use of pulverized coal and thus freed from the limitations referred to, on which superior results may be anticipated. Proper volume and arrangement of furnace and simplicity in preparation and conveying equipment are the most important requisites of the successful installation.

Weighing the results so far obtained, we believe that the scope of application of pulverization to the steam power plant may be defined about as follows:

1 For a wide range of low-grade coals which only with great difficulty, if at all, can be handled on existing forms of mechanical stoker, pulverization offers a satisfactory means of efficient combustion.

2 For relatively higher-grade coals and very high in price, the slightly improved efficiency obtainable by combustion in pulverized form may frequently be sufficient to warrant adoption where size of the installation and annual load factor are such as to make small percentages in combustion efficiency of large moment in operating cost.

3 For reasonably good grades of coal available at moderate price, it is doubtful if the expense and complications of the pulverizing equipment can be justified—except in very large installations or in case of a very high annual load factor.

With regard to the comparatively recent development of unit pulverizing equipments, one or more for each boiler, the following report from the Erie City Iron Works is quoted:

We have been conducting experiments in the burning of powdered coal under a power boiler. The pulverizing equipment is that manufactured by the Aero Pulverizing Company. The pulverizer is direct-connected to a variable speed motor. The coal is fed directly from our coal bunkers into a funnel-shaped hopper at the feed end of the pulverizer. The fuel is burned in a water-jacketed furnace applied to one of our old-style horizontal water-tube boilers. In connection with the test data which we give we wish to call attention to the fact that the boiler has been in service a great many years and the setting is far from being air-tight, thereby reducing the overall efficiency, which would otherwise be greater.

We are at present experimenting with the pulverizer itself and expect in the near future to make improvments therein which will result in a considerably higher degree of fineness, which in turn should result in a higher overall efficiency being obtained. We also expect to produce this greater degree of fineness of the pulverization at a lower power consumption.

A synopsis of the test referred to which was made in accordance with the Short Form Boiler Test advised by the Boiler Test Committee of the A.S.M.E. is as follows:

Percentage of ash in dry coal	11.47	
Calorific value of 1 lb. of dry coal	13,136	B.t.u.
Equivalent average per hr. from and at 212 deg. per sq. ft. of water heating surface	5.6	lb.
Percentage of rated capacity developed	162.6	%
Equivalent evaporation from and at 212 deg. per lb. of dry coal	10.08	
Equivalent evaporation from and at 212 deg. per lb. of combustible	11.38	
Efficiency of boiler and furnace based on combustible	74.4	%
Furnace temperature just within furnace	2,487	deg.
Stack temperature	508	deg.
Speed of pulverizer	1,480	r.p.m.
Lb. of coal as fired per hr.	2,391	
Kw-hr. per ton of wet coal pulverized	31.	
Per cent moisture in coal before pulverized	6.44	
Per cent moisture in coal after	1.78	
Per cent through 200 mesh screen	41.6	
Per cent through 100 mesh screen	66.1	
Per cent through 65 mesh screen	79.8	
Per cent on 65 mesh screen	20.2	
Volatile in coal	30.3	%
Fixed carbon in coal	52.52	%
Ash	10.73	%
Sulphur	2.45	%
Draft in furnace	0.03	in.
Draft in damper	0.11	in.
CO_2	16.41	%
O_2	2.10	%
CO	0.11	%
Excess air	10.14	%

The coal was fed into the furnace at the front of the boiler through a Y connection, each branch of the Y being 12¼ in. in diameter, this Y being directly connected to the pulverizer. No trouble was experienced due to Y connection clogging up.

Water Purification—The Use of Evaporators

In marine service it has long been common practice to supply pure make-up water for the boilers and other purposes from sea water by means of evaporators. The use of evaporators for supplying make-up water for generating stations has come into use only during the past four or five years. One of the first widely discussed installations of evaporators was that of the Buffalo General Electric Company. The following is from a letter from H. M. Cushing, Mechanical Engineer, giving information upon the operation of the evaporators:

We have installed two 30,000-lb.-per-hour, Griscom-Russell three-unit, double-effect evaporators, taking steam at 200 lb. saturated. This

is obtained from a 275-lb. 275-deg. high-pressure line, by means of a reducing valve and desuperheater. The first equipment was installed in November, 1916, and the second one in April, 1919.

Our make-up runs between 5 per cent and 7 per cent. We have some reserve capacity in the evaporator equipment. For the year 1919 we evaporated 14,000,000 gal. of water.

In regard to economy, when one considers the one factor of cost of treated water per 1000 gal. of water used, the evaporator system will figure most expensive, but, although we have operated our boilers continuously from eight to ten hours a day at 300 per cent of rating, often operating at 400 per cent of rating for an hour at a time, we have had practically no boiler trouble, and none whatever traceable to the heavy loads which the boilers have been called upon to carry. We attribute this to the use of the evaporator system for obtaining our boiler make-up. We have had no pitting in our boilers or elsewhere on the feedwater system, although both the manufacturers and ourselves have searched diligently for signs of it.

The advantages and disadvantages of evaporators are given by the Committee in their report and are here summarized in brief form:

Advantages:

1 Practical elimination of boiler blowdown, which ranges from one to three per cent of the total feedwater.

2 Improvement in heat transfer due to elimination of scale.

3 Operation of the boilers over longer periods of time without shutdown.

4 Low operating cost of evaporation, which is automatic.

5 Almost entirely and permanently eliminates bad feedwater troubles.

Disadvantages:

1 Distortion of plant heat balance unless the entire electrical and steam-driven auxiliary system is laid out for the use of evaporators. The low thermal loss of an evaporator system depends on the fact that the latent heat of the vapor from one "effect" is used either as live steam in the next or for heating the feedwater above 210 deg. in a closed feedwater heater, or to 210 deg. in an open feedwater heater. Each "effect" used reduces the amount of vapor to be disposed of and consequently the amount of heat-balance distortion, but increases proportionately the first cost of the equipment. The "two-effect" system with vapor from the second effect going to the feedwater heater seems to be the more common layout for generating stations.

2 High first cost. If the proportion of make-up to total feedwater runs much over 8 or 9 per cent, either the heat-balance distortion is very great or the installation cost due to additional effects and perhaps a closed heater makes the cost of installation correspondingly high. Consequently there is an economic point somewhere around 10 per cent of make-up beyond which it does not pay to put in evaporators except in very special cases.

3 Leakage in condensers, sealing glands, etc., reduce the advantages of an evaporator system.

Short Abstracts of the Month

AERONAUTICS

RESULTS OF TESTS ON RADIATORS FOR AIRCRAFT ENGINES, H. C. Dickinson, Mem. Am. Soc. M. E., W. S. James and R. V. Kleinschmidt. The present report is the fourth of a series of reports on airplane radiators, incorporating the results of experimental work at the Bureau of Standards under the joint auspices of that Bureau, the Aviation Departments of the Army, and the National Advisory Committee for Aeronautics.

Part I shows in tables and curves the results of measurements of geometrical characteristics of 59 types of radiators, together with such physical properties as heat transfer, head resistance, air flow through the core, power absorbed, and figure of merit. In most cases the properties are shown for speeds running up to 120 miles per hour.

The terms used in describing the radiators and their performance are defined, the more evident relations between the properties and characteristics are stated, and applications of the results to the design of a radiator are pointed out.

It is shown that the most efficient type of radiator tested, for use at high speeds and mounted in "unobstructed" positions on the aircraft, is one whose water tubes are flat hollow plates, placed edgewise to the air stream, and continuous from front to rear of the radiator.

Part II shows in curves the pressure heads required to produce given rates of flow of water in twelve sections of radiator, each of a different type, briefly described and shown in photographs, but each with a core 8 in. square. The methods used in the tests and in computation are stated in detail, and a method is developed for estimating, by the use of twelve sets of auxiliary curves, the pressure head required for a given rate of water flow in each type of radiator, when of any size, on the assumption that losses of head at inlet and outlet of the water tubes are negligible in comparison with the resistance in the tubes of the 8-in. sections. (Synopsis of Report No. 63, *National Advisory Committee for Aeronautics*, 1920, *e*).

AIR MACHINERY

DESIGN OF AIR DUCTS, J. C. Recommendations and chart for the determination of velocity in air ducts. The writer claims that in many cases the designer improperly figures the main duct as equal in area to the aggregate of the several branches, which gives to the main duct excessive proportions. Also an arbitrary velocity for the main duct is assumed which is considerably higher than that in the branches, with the result that the velocity for the main is excessive, the branches nearest the fan do all the work, and unnecessary use of metal is involved in making the duct larger than is really required.

In dust-extraction work it is important to maintain a velocity in the main duct equal to if not slightly greater than the velocity in the branches, so that no particle of dust is released from suspension until the dust separator is reached.

To solve this sort of problem the author plotted a chart (Fig. 1), the method of using it being as follows:

Suppose we require the size of main duct necessary to deal with fifty 5-in.-diameter branches. Let the eye follow up the line indicating 50 branches until the curve for 5-in. branches is encountered. If we now look along the horizontal line through the intersection of the said line and curve we obtain 24 in. diameter as the size required on the scale on the left-hand side of the chart. Now, fifty 5-in. branches total 981.75 sq. in., while the 24-in.-diameter main gives only 452.39 sq. in. This difference is brought about by the fact that there is a relatively greater frictional resistance offered by the smaller-diameter pipes owing to the factor (perimeter divided by sectional area) increasing as the diameter becomes less and less.

While the chart was prepared for 100 branches, the size of the main necessary to take the larger number of branches may be found (provided the main does not exceed 60 in. in diameter) by dividing the total number of branches into equal groups not exceeding 100 each, then finding the size of pipe required for each group, and finally looking up the size of main capable of dealing with these larger pipes. (*Mechanical World*, vol. 67, no. 1743, May 28, 1920, p. 346, 1 fig., *pA*).

BUREAU OF STANDARDS

THE SAYBOLT VISCOSITY OF BLENDS, Winslow H. Herschel. It has long been recognized that the viscosity of a mixture or blend of two oils is less than the arithmetical mean between the viscosities of the component oils. This is true whether viscosities are expressed in Saybolt seconds, poises or any other known unit of viscosity. For definite chemical compounds which are inert with respect to each other, a formula has been found which gives the viscosities of mixtures with great accuracy, but this formula cannot be used with oils whose molecular weights are not known.

For the purpose at hand, the best available formula was found to be

$$\log \mu = v_1 \log \mu_1 + v_2 \log \mu_2 \quad \ldots\ldots\ldots\ldots [1]$$

where μ, μ_1 and μ_2 are the viscosities, in poises, of the blend and of the component oils, and v_1 and v_2 are the percentage volume concentrations. Expressed in words, Equation [1] shows that the

viscosity of a blend is the weighted geometrical mean between the viscosities of the component oils, that is, the logarithms of the viscosities are additive.

If it is assumed that a Saybolt viscosimeter is used, the viscosity in poises may be obtained by the formula—

$$\mu = [0.00220\ t - (1.80/t)]\gamma \quad \ldots\ldots\ldots\ldots [2]$$

where t is the time of flow, or Saybolt viscosity, in seconds, and γ the density of the oil at the temperature of test, in grams per cc.

It was found that the viscosities of blends, as determined by test, agreed in some cases fairly closely with the viscosities estimated from Equations [1] and [2], but the estimated value was always too low when there was a considerable difference between the viscosities of the component oils. For given component oils, the error increased as the amount of the lighter oil increased, reaching a maximum in a blend containing about 60 per cent of the lighter oil. It was also found that the percentage of error varied with the source of the crude oils, the maximum error being obtained if a heavy naphthene-base oil was blended with a light paraffin-base oil, and the minimum error being found with a blend of heavy paraffin and light naphthene oils.

In order to carry the difference in viscosity to an extreme, a heavy naphthene-base oil was mixed with aviation gasoline, and the error in estimating the viscosity of the blend was found to be 221 per cent. But even in this case the viscosity determined by experiment was not as low as would have been estimated on the assumption that the reciprocal of viscosities are additive, a rule sometimes advocated as the true law of mixtures. Within the range of viscosities actually employed in blending operations, it was found that the maximum error in the viscosity calculated from the logarithmic rule would be 33 per cent for naphthene-base oils or 25 per cent for paraffin oils. A diagram was obtained for estimating the correction factor to be applied to viscosities of blends as calculated from the logarithmic rule. It is believed that with the help of this diagram the viscosity of a blend may be estimated with an error not greatly in excess in determining the viscosity of the component oils. (Abstract of *Technologic Paper of the Bureau of Standards* No. 164, *ep*)

ENGINEERING MATERIALS

How Shortages of Metals Were Met During the War in Germany

WAR EXPEDIENTS IN THE FIELD OF METALS IN GERMANY, Albert Wuerth. The shortage of many metals in Germany during the period of the war forced manufacturers to resort to some interesting expedients which the present article describes. It further discusses the particularly important point as to the extent to which war practice in this field is likely to be maintained with the coming of peace conditions and restoration of the availability of the usual materials.

Engine and Pump Manufacture. Crankshaft housings for submarine engines have to be built of a special bronze having very high mechanical qualities, such as high tensile strength and high percentage of elongation. Since the beginning of 1915, due to the shortage of metals, these crankshaft housings were made of cast steel, which did not lead to any particular difficulties and, indeed, with the construction of larger sizes of submarine engines, proved to be an advantage, as it gave to the housing a greater rigidity. On the other hand, the machinability of the material proved to be poorer than that of bronze.

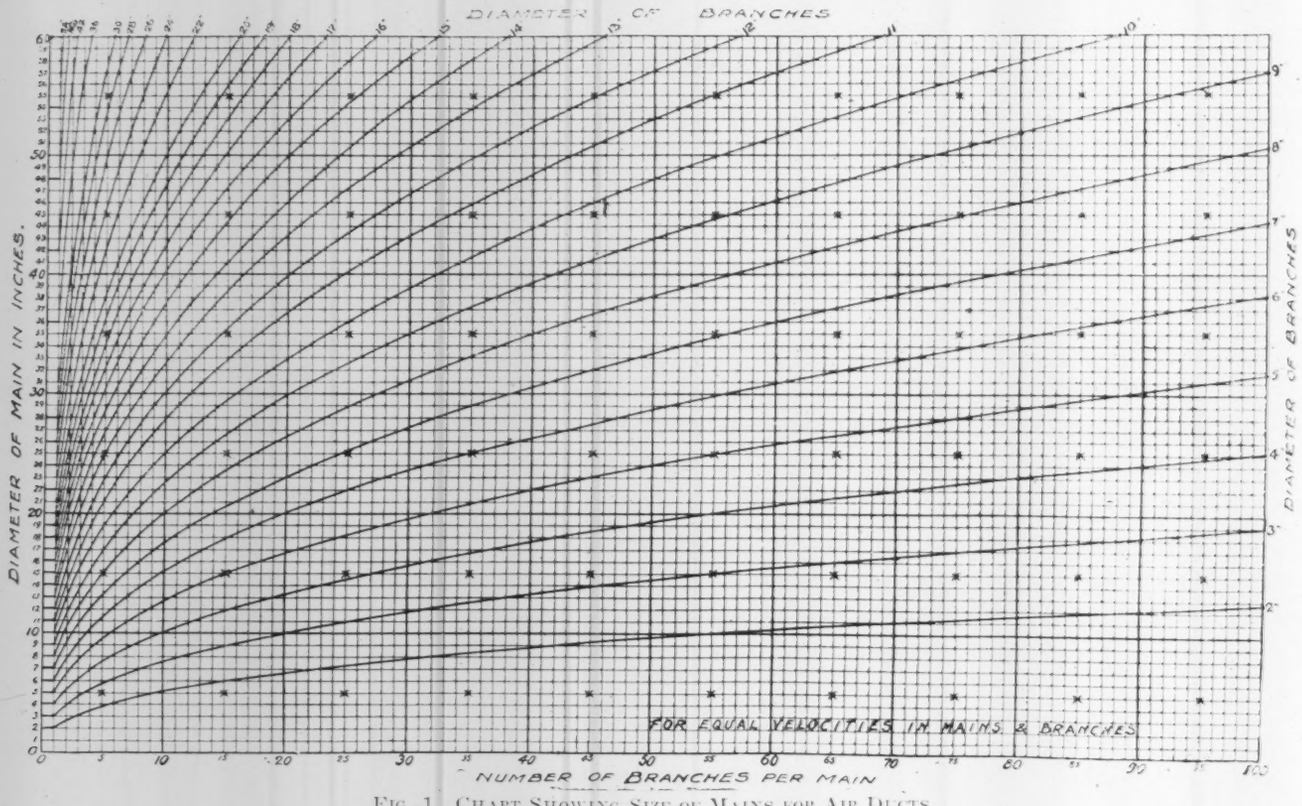

DIAMETER OF BRANCHES
DIAMETER OF MAIN IN INCHES.
DIAMETER OF BRANCHES
FOR EQUAL VELOCITIES IN MAINS & BRANCHES
NUMBER OF BRANCHES PER MAIN

FIG. 1 CHART SHOWING SIZE OF MAINS FOR AIR DUCTS

All the screws, bushings, etc., which before the war were made of bronze or copper castings, had to be of iron and sherardized in order to protect them against rust. (This was done by the Schoop process.) On the other hand, parts which used to be made of aluminum castings were during the war made of thin sheet iron and then galvanized.

Considerable trouble was experienced with piping. The former copper piping was replaced by steel piping galvanized inside and out. The zinc coating did not prove satisfactory, however, as it was rapidly eaten away by sea water and salty sea air. The pipes therefore had to be protected by lead, which, however, did not adhere well to the steel and chipped off easily under mechanical influences. It proved necessary to protect the piping by two coats of metal—zinc first and lead afterward. This required great skill in manufacture and a close control of the temperatures at which the metals were applied.

Vigorous efforts were made to conserve tin. Bronze bushings or parts under heavy stress (such as steering gears) used to be made of a bronze with a 15.5 per cent tin content. During the war these bronze bushings were made of an alloy containing about 30 per cent less tin and were not cast in sand, but in a metal mold so as to give them a greater hardness. This was based on investigations made in 1910 by Heyn and Bauer, which would indicate that the hardness of a copper-tin alloy is really a matter which may be controlled either by variation in tin content or by the proper control of temperature conditions during cooling, and, in particular, velocity of cooling. It should clearly be borne in mind that this hardening by rapid cooling is possible only with bronzes and not with brasses.

Bronze bushings with a tin content of 10 per cent were machined and after having been set in their seats were hardened on their surfaces by having a conical mandrel driven in under high hydraulic pressure.

Parts not subject to heavy stresses were made of zinc castings, and it appears that the strength of such parts was materially affected by the heat treatment which they used to undergo.

An effort was made to produce a bearing metal containing 52 per cent tin, 42 per cent lead, 2 per cent copper and 14 per cent antimony, but it has not as yet been carried to a successful conclusion.

Jet Apparatus. Considerable trouble was experienced in attempts to find substitute metals for use in jet apparatus, by which are meant nozzles and their equivalents through which water, steam, gases or acids are discharged under pressure. Here, in addition to other conditions, the tendency to corrosion and erosion had to be met. This latter particularly when the material discharged through the nozzle contained sand or suspended solids.

In particular, in injectors, attempts were made to substitute cast-iron nozzles for bronze, but it was found that the former did not stand up well when used either with steam or hot water. The inner wall of the nozzle was strongly corroded, which interfered with the efficiency of the apparatus. Tests were begun with various aluminum alloys for use in nozzles, but have not yet been concluded, and promising results were obtained with aluminum bronze containing 90 per cent copper and 10 per cent aluminum. This, however, would bring a saving only in tin and not in copper.

The water-atomizing nozzles in humidifying apparatus used to be made of bronze. During the war an attempt was made to make the housings out of so-called zinc bronze, leaving the general shape of the device the same as formerly and using bronze nozzles. It was found that housings so made would not stand up in service and broke easily and developed leaks. The shape was then altered and the main housing made of cast iron with screwed-in zinc bushings for water inlets.

In air nozzles made of zinc bronze unevenness of the surfaces rapidly developed, which made the atomizing incomplete and irregular. The reason for this was found to be the formation of zinc hydroxide, and the result of it was that much greater skill in attendance was necessary in order that good atomizing might be obtained.

Oil Preheaters. In Germany, during the war, the development of oil preheaters was of considerable interest. In ante-bellum days the jackets and covers of oil preheaters were made of bronze. Attempts were made to use steel castings as substitutes for bronze in covers, which led to certain mechanical troubles. The covers were then made with heavier walls and out of cast iron, but broke easily.

The design was then entirely changed, the brass tubes replaced by steel tubes and the cover made of thick wrought-iron disks, while the jackets were made of steel blocks. This latter did not prove satisfactory because in the machining of the blocks close to 90 per cent of the material was wasted which made the process expensive and not economical, in addition to which the riveting of the parts proved to be difficult. The jackets were made out of sheets and held in place by a combination of riveting and welding. (*Stahl und Eisen*, no. 13, April 1, 1920, pp. 421-426, 14 figs., serial article, not concluded, *d*)

FUELS AND FIRING

BURNING COKE BREEZE ON UNDERFEED STOKERS, F. A. DeBoos. Coke breeze, by which name the fine abrasions which are a by-product of coke manufacture are known, amounts to approximately 6 per cent of the total coke produced. In general, 40 per cent will pass through ½-in. mesh screen and 60 per cent through a 1⅛-in. mesh. These sizes, however, are too small for blast-furnace work, and, in particular, for the finer particles ranging from dust to sizes around ⅜ in., the demand is very slight.

The material has a good heating value, averaging on a dry basis 10,000 to 11,000 B. t. u., but is difficult to burn efficiently. Various attempts have been made to burn it either mixed with coal or on specially designed stokers of the chain-grate type, but there are objections to either of these methods. Furthermore, in many plants the amounts of coke breeze available are not sufficient to give the full power demanded, and coal-fired boilers must be used. In such installations there is a demand for a stoker which will burn varying mixtures of coke breeze and coal and which will have the ability not only to give good ratings and good efficiencies with such mixtures but will also be capable of securing extremely high ratings with proper efficiencies when burning all coal.

The author calls attention to the requirements for burning coke breeze and coal mixtures and also results of tests made at the Michigan Limestone and Chemical Co., Rogers City, Mich., with Jones A-C multiple-retort-type stokers.

In these tests a mixture of 225 lb. of coke breeze to 100 lb. of coal was burned with an efficiency of 65.6 per cent at 155.5 per cent rating; also with a mixture of 325 lb. coke breeze to 100 lb. coal, 141.1 per cent rating was developed with 59.1 per cent efficiency.

During the summer of 1919 tests were also made by the Ford Motor Co., in the course of which a mixture of two parts coke breeze to one part coal was first used, and then changed to three parts coke breeze to one part coal. As a result of these tests they are now burning at the Ford Hospital, Detroit, Mich., a mixture of two parts coke breeze and one part coal quite successfully and at a considerable saving in cost. The coke breeze is stored in a bin separate from the coal and the charge is mixed by dropping alternate charges of coke breeze and coal into the traveling bin. The mixture then descends through a short chute into the hopper of the stoker.

When coke breeze and coal mixtures are burned light air pressure is necessary, as otherwise the fine particles of breeze are blown up into the baffling of the boiler or down on to the dump plate with the objectionable result that holes will develop in the fire.

This makes it necessary to keep the fuel bed fairly thin, as otherwise heavy clinkers will develop and make it impossible to use the light air pressure. Also coke breeze-coal mixtures must be held together so that the particles of coke may "freeze", thus permitting the air pressure to facilitate combustion. (*The Blast Furnace and Steel Plant*, vol. 8, no. 6, June, 1920, pp. 362-364, 2 figs., *pe*.)

INTERNAL-COMBUSTION ENGINES

Fuel-Injection and Regulation Methods in Heavy-Oil Engines

THE APPLICATION OF LIQUID FUEL TO OIL ENGINES, A. J. Nilson. The author discusses the subject of injection and devotes considerable space to the description of various systems for its regulation. Of interest is the Pasel design (Fig. 2) for cutting out three-quarters of the pulverizer rings and giving the fuel a less tortuous path.

A groove is cut in the valve spindle down to the level of the bottom pulverizer ring and the entry to this groove or channel at the upper end is blanked by a sleeve having two ports opposite one another and coinciding with the groove in the valve spindle. This sleeve is operated from the outside and can be turned so as to close the aperture as may be required.

Another method of controlling the injection shown operates electrically and was designed by Mirrless, Bickerton and Day.

Several solid-injection systems are also described. Of particular interest is the system used in the Blackstone engine, where duplex injection is employed, which is a compromise between the true Diesel air-injection engine and the solid-injection vaporizer type of the semi-Diesel. In this system (Fig. 3) blast air at a pressure of 350 lb. per sq. in. is taken to a pair of fuel inlet valves or atomizers, one of which opens with a slight

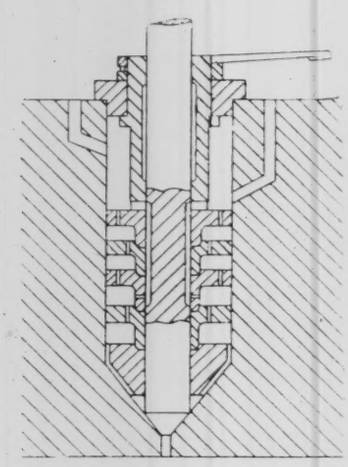


FIG. 2 PASEL BLAST-AIR INJECTION REGULATION VALVE (THE VARIABLE-RESISTANCE TYPE)

lead on the other. The leading valve delivers a small charge of oil to a hot bulb and maintains this automatically and continuously at the required temperature for igniting the main charge at all conditions of load. The jet of flame from this hot bulb is arranged to escape into the main cylinder through an orifice which deflects the flame obliquely into the spray from the main fuel valve, causing the charge to burn rather than explode. The initial compression in the main cylinder is only 150 lb. per sq. in. and the engine might be described as a low-compression Diesel with pilot ignition were it not that the ignition

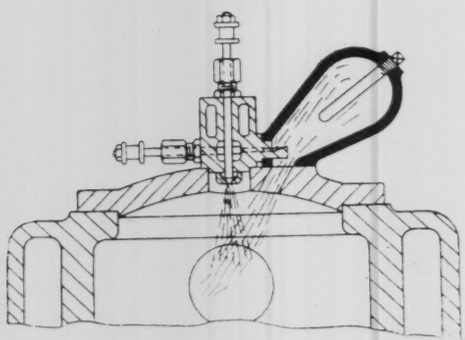


FIG. 3 BLACKSTONE DUPLEX-INJECTION TYPE OF CYLINDER HEAD

originates from the heat of a hot bulb and not as a result of air compression.

The Crossley oil engine is also described in considerable detail (compare MECHANICAL ENGINEERING, December, 1919, p. 896).

The subject of fuel ignition is discussed at some length and a good deal of attention is paid to the employment of tar oils as fuel for Diesel engines.

In this connection the choking of the pulverizer with black deposit is considered and the sleeve pulverizer introduced by P. H. Smith is described. It is stated that with this type of fuel valve the accumulation of black deposit is not as objectionable as in the standard type. The same trouble may be dealt with by running the engine for about fifteen minutes on gasoline every five or six hours, which clears out most of the deposit and renders it possible to run for long periods on tar oil without dismantling the fuel valve.

It is also stated that lignite oils are perfectly satisfactory in any Diesel engine which will run on a petroleum gas oil and no special apparatus is required as in the case of coal-tar oils. (*Journal of The Institution of Petroleum Technologists*, vol. 6, no. 22, April, 1920, pp. 141-165, 16 figs., and discussion pp. 165-185, 3 figs., *dq*).

Analysis of Conditions Affecting Slow Running of Automobile-Type Engines

THE LIMITS OF SLOW RUNNING, A. Johnson. It is well-known that as regards the ability to work efficiently at a low rate of revolution, the ordinary gasoline engine compares unfavorably with the steam engine. This is the reason for the use of change-speed gear drives in automobiles and numerous attempts to produce a slipping clutch (electric transmission).

As regards the mechanics of slow running, it may be noted that the low rate of speed is favorable to the induction of a large quantity of explosive mixture and thus to the attainment of a high pressure at the beginning of the compression stroke. On the other hand, the compression stroke itself is performed slowly and therefore the mean effective pressure is comparatively low. The balance of these two opposing causes, other things being

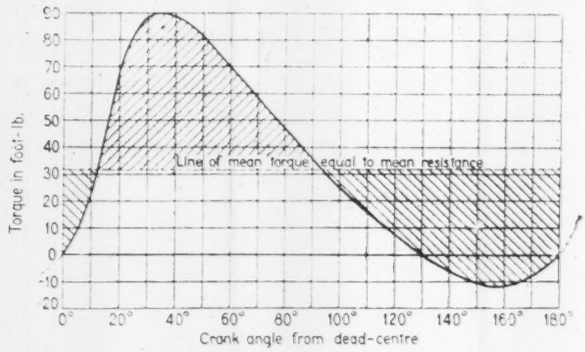


FIG. 4 TORQUE CURVE FOR A 4-CYLINDER ENGINE RUNNING LIGHT

equal, determines the speed at which the mean effective pressure is a maximum.

Fig. 4 shows an approximate torque curve for a 4-cylinder engine, 4-in. bore by 5-in. stroke, running light. The internal friction in this engine is estimated to be equal to a constant torque of 32 ft-lb. When the crank is at either dead center the torque is zero and does not become equal to the frictional load until the crank has turned through 12 deg. From 12 deg. to 93 deg. past the dead center the engine torque is in excess of the load, and from 93 deg. to 192 deg. it is again insufficient to overcome the resistance.

Because of this the revolving mass of the engine is accelerated between 12 deg. and 93 deg. and decelerated between 93 deg. and 192 deg.

The shaded area above the line of mean torque in the diagram represents work done by the engine in accelerating the flywheel or equivalent revolving mass, and the shaded area below that line represents work given up by the flywheel to compensate for the defect of engine torque. These two areas must be equal if the rate of revolution is to return to the same value at each 12 deg. of crank advance from either dead center, and considering the total lower area, it will be found by measuring the diagram that the mean height represents a torque of 28 ft-lb. exerted during the crank's passage through 99 deg.

The work done or given up by the flywheel is therefore $28 \times (99/360) \times 2\pi = 48.38$ ft-lb., which is also the amount of work previously done by the engine in accelerating the flywheel under the assumption made above.

Assigning certain arbitrary values to the dimensions and weight of the flywheel or its equivalents, the writer obtains a mean rate of revolution for a given engine of 33 r.p.m., which is the absolute minimum rate of revolution for the engine and flywheel, assuming, however, that at such a slow speed the pressure in the cylinder would not vanish by cooling.

This rate of revolution is, however, the mean of zero and 66.43 r.p.m., which is the rate of revolution attained by the crank at 93 deg. past the dead center, and it is obvious that such extreme variations of rate within half a revolution cannot be permitted. If an arbitrary limit be set to the effect that the variation of speed shall not exceed 10 per cent of the maximum, it will be found that the mean rate of revolution is roughly 145 r.p.m., which is the lowest rate at which the engine will run light with a specified degree of regularity.

To determine whether the same flywheel running on the same limit of regularity will permit the engine under full load to run at a reasonably slow speed, it is assumed that in the full-load torque all the ordinates of the light-load diagram are multiplied by five. This, according to the author's calculation, brings the mean r.p.m. at slow speed under full load to about 324 r.p.m. This is probably slower than the engine will ever be required to run and will, in many cases, be lower than the speed of maximum mean effective pressure and therefore lower than the lowest speed at which the engine can run at full load. (*The Automobile Engineer*, vol. 10, no. 139, June 1920, pp. 231-232, 1 fig., *f*)

LUBRICATION (See also Bureau of Standards)

GRAPHITE LUBRICANTS, W. R. G. Atkins. In a brief paper the author describes the various forms of graphite lubricants and comes to the following conclusion:

It is obvious that to try to use graphite as a lubricant instead of oil would be useless, as solid friction is always greater than liquid friction. The oil used must be able to keep the metallic surfaces apart, either by its oiliness, its power of creeping with unbroken film over the metal, which necessitates a low surface tension, or by its viscosity, whereby it is carried along by the rotating portions, and wedged in between them and the fixed portions. To use an oil of viscosity more than sufficient to do this is wasteful, as energy is lost in shearing oil. Liquid lubricants, however, are greatly influenced by rise of temperature, and a decrease in viscosity of about 3 per cent per degree centigrade is quite a usual value for thick oils between 60 and 90 deg. cent. At cylinder temperatures all oils have very much the same viscosity. Under such severe conditions liquid oil films are apt to break, so the presence of a solid lubricant like graphite, which is almost entirely unaffected by such temperatures, is highly desirable. Graphite, then, may be considered as a lubricant of special value for cylinders and valves of internal-combustion engines. It is also of value for use on bearings, especially when subjected to heavy pressure, in which case the oil film may fail. A graphite film in a bearing, besides reducing the solid friction of metal to metal, also provides a skin which is renewed from the oil, this skin being worn away instead of the metal. After graphite has been in use in an engine for some time the amount in the oil (always a very small quantity) may be further reduced, for once the graphite surface is formed a very small quantity suffices to maintain it. It is difficult to explain why the use of graphite reduces the consumption of lubricating oil, but it undoubtedly does so. The film deposited is too thin sensibly to alter the clearances. The explanation which appears the most probable is that by reducing the friction and the eddy currents in the oil due to surface irregularities, the temperature of the oil film is, on an average, reduced, and its viscosity being on that account greater, its rate of flow is diminished. It is also possible that, on the cylinder walls, where oil probably vaporizes with the fuel, a certain residue of graphite remains, and in this case the clearances between piston rings and cylinder walls may be slightly reduced. Apart, however, from any explanation of its action, the saving is an established fact, and in certain cases it appears that power is also saved. (*The Automobile Engineer*, vol. 10, no. 139, June 1920, pp. 239-240, *g*)

MACHINE ELEMENTS AND DESIGN

Cam Design for Radial and Rotary Engines

CAMS FOR RADIAL AND ROTARY ENGINES, Wm. John Walker. The writer attempts to determine by a general method whether or not any multi-lobed cam will, by being geared to run at an appropriate speed, perform its functions correctly. The method given by the author is applicable to the problem of designing a cam disk geared to revolve in the same direction as the crankshaft.

In Fig. 5 is illustrated a tappet distribution for a 9-cylinder engine, but the tappets have been numbered to correspond to an engine having any number of cylinders, n. The cam is shown with only one lobe, so that the figure is equally applicable for a cam revolving in either the same or in the opposite direction to that of the crankshaft.

The author shows, among other things, that the correct angular distance between two consecutive lobes is $4\pi/(n-1)$ radians, and also that the total number of lobes of the cam disk must be $(n-1)/2$.

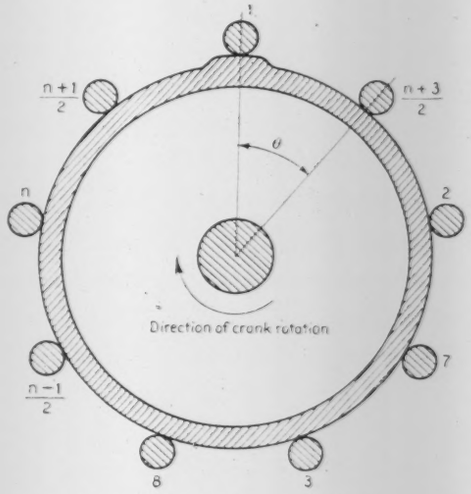


FIG. 5 TAPPET DISTRIBUTION FOR A 9-CYLINDER RADIAL AND ROTARY ENGINE

If the cam is geared to revolve in the same direction as the crankshaft, it must be geared to revolve at $1/(n+1)\times$ the speed of rotation of the crankshaft. Also the angular distance between two consecutive lobes must be $(n+1)/2$.

Thus, in the case of a 9-cylinder radial stationary engine, the two possible multi-lobed cams are either (1) the 4-lobed cam geared to run at $\frac{1}{8}$ crankshaft speed in the direction opposite to that of the crankshaft, or (2) a 5-lobed cam geared to run at 1/10 the speed of, and in the same direction as, the crankshaft. The same applies to the case of the rotary engine, the cylinder speed being considered instead of the crankshaft speed. (*The Automobile Engineer*, vol. 10, no. 139, June 1920, p. 241, 1 fig., *f*)

Emergency Design of Bicycle Chain to Meet Present Shortage

NEW BICYCLE CHAIN. Last May a conference of jobbers in bicycle supplies was called together at the plant of the Diamond Chain Manufacturing Co., Indianapolis, to discuss the serious bicycle-chain shortage brought about by all the difficulties with which the majority of manufacturers have been confronted for the past several years. This shortage was the controlling factor in bringing about the situation where it is practically impossible to secure chains for replacements.

From reports made it would appear that the mills from which material for the rollers and bushings of the usual roller chains are obtained had been in constant labor trouble since July, 1919, and were closed completely from the end of September to De-

cember during the steel strike, while the production of some types of chains was not resumed until the middle of January. In addition, the working forces were seriously handicapped by the influenza epidemic during January and February, when for a period of about six weeks the absences among operators ranged from 25 to 45 per cent.

Under these conditions the Diamond Chain Manufacturing Co. recommended the employment of a new type of chain, or rather

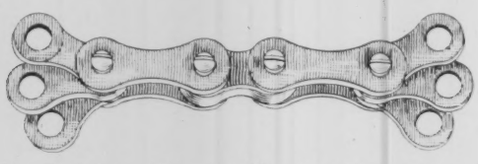


FIG. 6 THE ONE-INCH PITCH 3/16-INCH LEAF BLOCK CHAIN OF THE DIAMOND CHAIN MANUFACTURING CO.

the revival of a type formerly used but produced by different methods.

With roller chains it is difficult to create increased production. The limiting factor is in the manufacture of bushings and rollers as the equipment for these parts is even now being driven to the limit. Material for these parts in increased quantity is not obtainable and the special machinery required for manufacture could not be produced under many months.

To meet this serious situation the leaf block chain (Fig. 6) has been designed. It is made up of a series of stampings and therefore does not require special machinery to produce it as is necessary in the production of roller and solid-block chains. It can also be assembled much quicker than either roller or solid-block chains. In general design it is similar to chains produced many years ago before the solid-block chain came on the market and is recommended especially for replacement business until the industry has picked up with the demand upon it. (*Motorcycle and Bicycle Illustrated*, May 13, 1920, pp. 37-39, 2 figs., *d*).

MECHANICAL PROCESSES

ROLLED PRODUCTS OF 99 PER CENT NICKEL, Edwin F. Cone. Ninety-nine per cent nickel can now be rolled into the various shapes into which mild steel is rolled; and not only that, but forgings have been attempted with success. It appears that nickel products can be fabricated with no more difficulty than those of

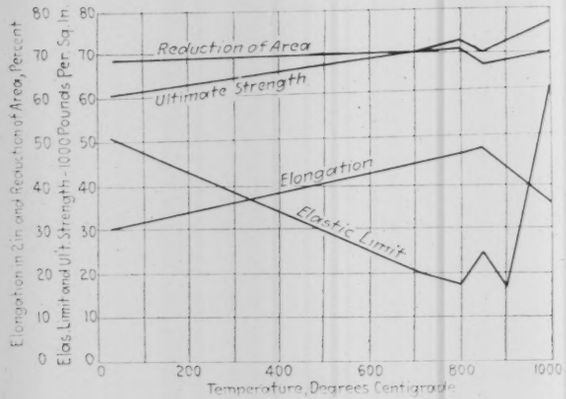


FIG. 7 THE PHYSICAL PROPERTIES OF 99 PER CENT ROLLED NICKEL

mild steel, and as the same apparatus is used for working the nickel as is used for steel, it is possible to alternate the rolling of steel and nickel products without any changes or adjustments in the machinery. This is done at the plant of the Nickel Alloys Company at Hyde, Clearfield County, Pa.

Pure nickel products are of value wherever non-corrodibility and ability to maintain an article in an antiseptic condition are of importance; for example, in dairy machinery, dyehouse equipment, etc. The new product is said to be malleable, can be welded to iron, steel or to itself, has a melting point of 1485 deg. cent. and the physical properties shown in Fig. 7.

The raw material is refined and specially treated in small 2- to 3-ton open-hearth furnaces. The hot metal is poured into ordinary ingot molds at a temperature of approximately 3200 deg. fahr. These ingots are later broken down under hammers or in rolls after the usual preheating. Sheets are rolled down in packs of 8 to 32 sheets to a thinness of 0.001 in.

The following data in addition to the curve are available as to the physical properties of the material:

Transverse test on a 1-in. diameter hot-rolled bar:	
Elastic limit	27,500 lb. fiber stress
Ultimate strength	84,300 lb. fiber stress
Modulus of elasticity	16,500,000 lb. fiber stress
Torsion test of a 1-in. rod, hot-rolled:	
Elastic limit	12,250 lb. fiber stress
Ultimate strength	80,800 lb. fiber stress
Degrees of twist per running inch	320 deg.
Complete twist in 24 in.	21 revolutions

The metal is of great flexibility and does not appear susceptible to the formation of scale, even under the most trying conditions. (*The Iron Age*, vol. 105, no. 25, June 17, 1920, pp. 1713-1716, 9 figs., *dA*)

MECHANICS

Load-Carrying Capacity of an Angular-Contact-Type Ball Bearing

LOAD CHARACTERISTICS OF RADIO-THRUST BEARINGS, F. C. Goldsmith. The article is a reply to one by F. W. Gurney which appeared in a previous issue of the *American Machinist*. The author is chief engineer of the New Departure Manufacturing Company.

The part which is of particular interest is that in which the author establishes an equation for the load-carrying possibility

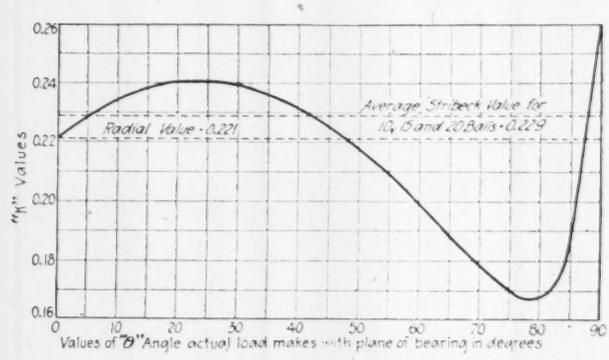


FIG. 8 CURVE SHOWING VARIABLE FACTOR AGAINST VALUES OF LOAD ANGLE IN A CERTAIN TYPE OF BALL BEARING

of an angular-contact type of ball bearing in terms of certain known quantities. The notation which the author uses is:

P = total resultant load on one ball row
P_o = load on bottom ball in direction of contact
θ = angle between line of load application and plane of balls
α = angle between balls in vertical plane
β = angle of contact, and
$\gamma_i = \omega_\eta = 0$

where ω is angle between line of load application and contact lines.

With this notation the author derives the formula

$$P = P_o \left\{ \cos(\theta - \beta) + \frac{2}{\cos^{1.5}(\theta - \beta)} \left[(\sin\theta \sin\beta + \cos\theta \cos\beta \cos\alpha)^{2.5} + (\sin\theta \sin\beta + \cos\theta \cos\beta \cos 2\alpha)^{2.5} + \ldots (\sin\theta \sin\beta + \cos\theta \cos\beta \cos\gamma_i\alpha)^{2.5} \right] \right\}$$

from which one can see that for any one value of the load angle θ all other quantities are known. By solving this equation for

bearings containing 10, 15 and 20 balls and letting θ vary through 90 deg. one can arrive at a variable factor which has a fixed value for each corresponding value of θ. Plotting these values of the variable factor against degrees of the angle of load application, the author obtains a curve from which, the angle of load application being given, one can pick the proper value of one of the principal bearing load factors.

In Fig. 8 is given such a curve showing the variable factor K in ordinates against values of the load factor θ as abscissæ for a popular line of thrust angular-contact type of ball bearings, the values of K being the average of bearings having 10, 15 and 20 balls.

In this figure, as a dotted line, is shown also the reciprocal of the number 0.229, which is the average value of the constant from the Stribeck equation for radial or annular ball bearings having 10, 15 and 20 balls. This is done to bring out the fact that for some load angles this bearing will carry a greater load than an annular bearing of the same size can carry, even as a pure radial load.

The following may be said as to the use of the curve in question: All speed-load catalog ratings are given as pure radial loads, and the corresponding value of K would be 0.221. Now, supposing the angle of load application happens to be 25 deg., the corresponding value of K would be 0.24, and in selecting the proper size of bearing from the catalog rating we would multiply the resultant load by 0.221 over 0.240 or

$$\text{Catalog load} = \frac{0.221}{0.240} \times \text{resultant load} = 0.92 \times \text{resultant load}$$

In case the load angle proved to be 85 deg.,

$$\text{Catalog load} = \frac{0.2210}{0.1675} \times \text{resultant load} = 1.32 \times \text{resultant load.}$$

After a careful study of this curve we can see that when the load angle is less than 48 deg. we really have in this angular-contact-type ball bearing a very excellent load-carrying device.

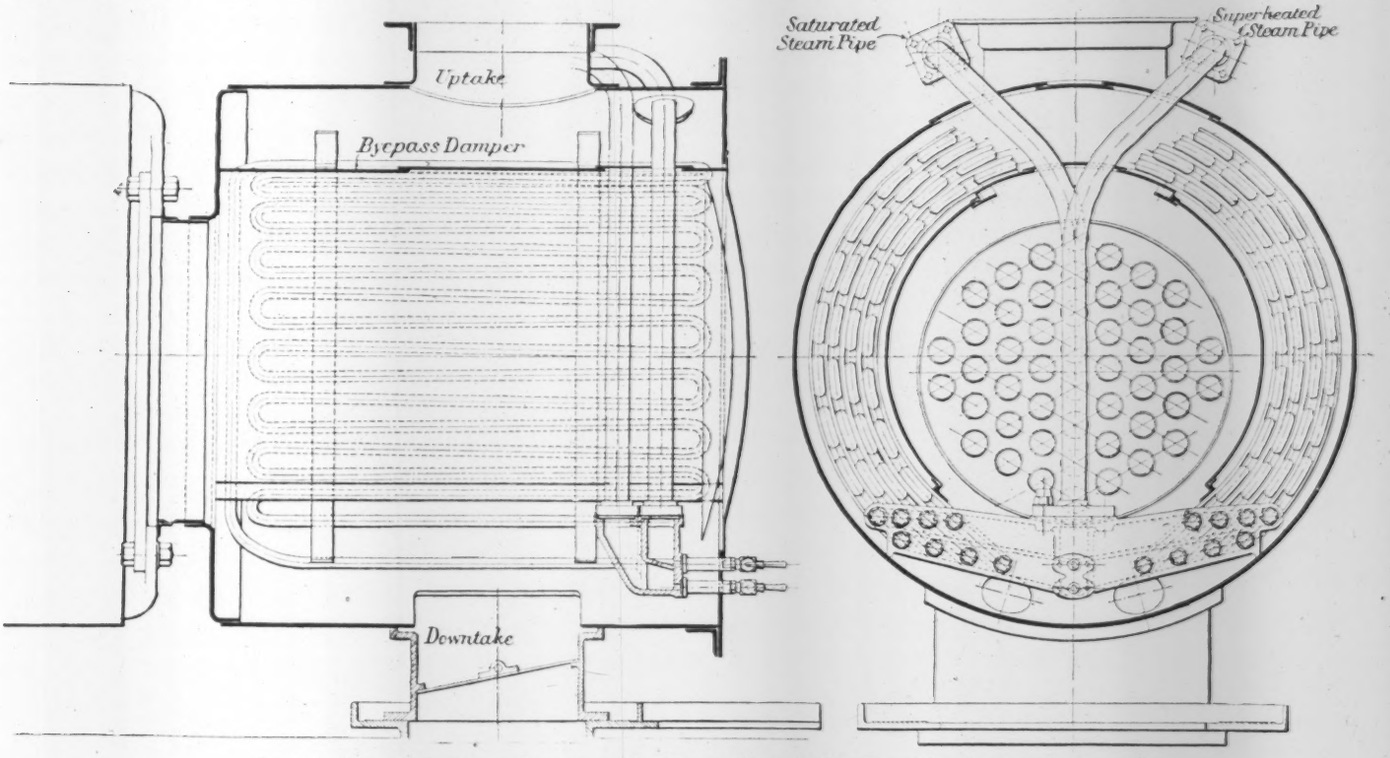
The author also gives an interesting curve sheet (Fig. 10 of the original article) such that after the radial and thrust loads have been determined one can readily arrive at the proper bearing size. (*American Machinist*, vol. 52, no. 23, June 3, 1920, pp. 1190-1196, 10 figs., *t*)

POWER PLANTS

COMPOUND LOCOMOBILE WITH SUPERHEATER. Description of the locomobile built by Marshall, Sons & Co., Ltd., Gainsborough, England.

The engine is a 2-cylinder compound mounted on a cylindrical tubular boiler. This latter is 6 ft. 1 in. in diameter and has a length of 16 ft. It is fitted with a single flue 4 ft. 3½ in. in external diameter and 7 ft. 7 in. long. The tubes are 129 in number and 2½ in. in external diameter, giving a total heating surface of 769 sq. ft., of which 79 sq. ft. represent the flue surface.

A smokebox superheater, Figs. 9 and 10, provides 600 sq. ft. while a horizontal feed heater through which the exhaust from the low-pressure cylinder passes on its way to the condenser furnishes 65 sq. ft. of heating surface. The boiler pressure is 180 lb. per sq. in. and in tests reported in the original article it was found that the coal consumption per brake horsepower per hour was 1.7 lb. running non-condensing and 1.39 lb. condensing with the heat value of coal of 11,500 B.t.u. The engine is furnished with a jet condenser, together with an Edwards-type vertical air pump. The feed pump is fixed to the air-pump casting and works off the same eccentric rod. The feed is passed through the tube at the feed heater. An injector is fitted to the boiler as a stand-by.



FIGS. 9 AND 10. SUPERHEATER OF MARSHALL, SONS & CO. COMBINED LOCOMOBILE

In connection with Figs. 9 and 10 it may be added that they represent the general arrangement of the superheater, but not the actual arrangement adopted for this size of engine. (*Engineering*, vol. 109, no. 2840, June 4, 1920, pp. 767-768, *d*)

STEAM ENGINEERING (See Power Plants)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A. S. M. E.

Research Association in Great Britain

IN addition to those listed in the March issue of MECHANICAL ENGINEERING (p. 181), the following Research Associations have received licenses from the Board of Trade under Section 20 of the Companies' Act of 1908:

The Glass Research Association, 50, Bedford Square, W. C. 2. Secretary, E. Quine, B. Sc.

The British Non-Ferrous Metals Research Association, 29, Paradise St., Birmingham. Secretary, E. A. Smith, A. R. S. M., M. Inst. M. M.

The following Rssociations have been approved, but not licensed:

British Music Industries Research Association
The British Refractory Materials Research Association
The Scottish Shale Oil Research Association
The British Leather Manufacturers' Research Association
The British Launderers' Research Association.

The following Associations are under consideration:

The British Electrical and Allied Industries Research Association
The British Aircraft Research Association.

The following Associations are preparing memorandum and Articles of Association:

Silk Manufacturers
Master Bakers and Confectioners
Cycle and Motor Cycle Manufacturers
Users of Liquid Fuels

Research Laboratories In and About Washington

The following list of laboratories has been prepared by Mr. C. A. Briggs, Associate Physicist of the Bureau of Standards:

Industrial Research Laboratories:
- Institute of Industrial Research, 19th & B Sts., N. W., Washington, D. C.
- National Canners' Association, 1739 H St., N. W., Washington, D. C.

Endowed Laboratories:
- Geophysical Laboratory of the Carnegie Institution
- Department of Terrestrial Magnetism of the Carnegie Institution.

Laboratories of Educational Institutions:
- American University
- Bliss Electrical School
- Catholic University
- Gallaudet College
- Georgetown University
- George Washington University
- St. John's College
- Trinity College
- Washington Missionary College.

Departmental Laboratories:
- Bureau of Chemistry—10 laboratories
- Other Bureaus of the Department of Agriculture—22 laboratories
- Coast and Geodetic Survey—3 laboratories
- Bureau of Standards
- Bureau of Mines—5 laboratories
- Navy Department—17 laboratories
- Smithsonian Institution—4 laboratories.

A—RESEARCH RESULTS

The purpose of this section of Engineering Research is to give the origin of research information which has been completed, to give a résumé of research results with formulæ or curves where such may be readily given, and to report results of non-extensive researches which in the opinion of the investigators do not warrant a paper.

Apparatus and Instruments A10-20 Thermal Expansion. A stretched-wire apparatus for measuring thermal expansion has been developed by Dr. Arthur W. Gray. This instrument is simpler in form than the one designed by him for the Bureau of Standards. The Report in *Chemical and Metallurgical Engineering* for Nov. 26, 1919, gives the form of apparatus together with results from its use. The instrument is simple and gives accurate readings. Address Dr. Arthur W. Gray, L. D. Caulk Company, Milford, Del.

Cellulose and Paper A1-20 Gas Masks in Pulp and Paper Mills. Gas masks of a nose-breathing type with canisters containing special chemicals are used in the digester house of the Forest Products Laboratory at Madison, Wis. This mask enables the operator to make ready repairs of SO_2 leaks under conditions otherwise unbearable. They are of great assistance in bleach rooms. Address Forest Products Laboratory, Madison, Wis.

Electric Power A3-20 Safe Use of Alternating Type of Coal-Cutting Equipment. L. C. Ilsley and E. J. Gleim have recently made a report to the Bureau of Mines on machines, circuits, protection and switches for alternating currents applied to coal-cutting equipment. Bureau of Mines, Washington, D. C. Address F. G. Cottrell, Director.

Fuels, Gas, Tar and Coke A6-20 Evaporation from Crude Oil. J. H. Wiggins, Assistant Petroleum Engineer of the Bureau of Mines, has recently made a report showing a yearly loss of nearly 827,000,000 from evaporation of crude oil in the Mid-Continent oil field. This amounts to 3 per cent of the total gasoline produced in the United States. The major portion of this evaporation occurs on the lease when the oil is still fresh. It is possible to eliminate two-thirds to four-fifths of this evaporation by protecting oil from free contact with air. Bureau of Mines, Washington, D. C. Address Director.

Fuels, Gas, Tar and Coke A7-20 The Peat Resources of Ireland. Special Report No. 2 of the Fuel Research Board of the Department of Scientific and Industrial Research of Great Britain by Professor Pierce F. Purcell is to be issued. The subjects treated are: Origin and formation of peat deposits, occurrence of trees in bogs, physical properties of peat, elimination of water, area and fuel content of Irish peat deposits, peat deposits of other countries, hand winning, mechanical winning, uses, utilization, allowable moisture for producer work, reclamation and cultivation of bogs. Price by post, 11d, obtained at Imperial House, Kingsway, London, W. C. 2.

Leather and Glue A2-20 Effect of Oils on Strength of Glues in Plywood. Plywood near machinery and tanks containing oils may be used with little danger of the joints becoming weak through the action of the oil or gasoline. Plywood panels glued with animal, vegetable, albumen and casein glues were immersed for nearly a year in engine oil and gasoline. All the glues weakened somewhat during the early part of the test, the animal and vegetable glues showing the greatest reduction in strength. The total loss was small, however. In only two or three instances did the strength of the casein or the blood albumen glues fall below 150 lb. per sq. in. The shear strength of the glue of 100 to 125 lb. per sq. in. was found in most cases. During 45 weeks the wood absorbed 60 per cent of its original weight of gasoline. Forest Products Laboratory, Madison, Wis. Address Director.

Machine Tools A1-20 Shearing Steel at High Temperature. Series No. 20 of the Engineering Experiment Station of the University of Missouri contains a paper by Guy D. Newton on Energy Necessary to Shear Steel at High Temperatures. Experiments were tried with a rotary shear and with a straight shear. The metal was heated in a gas furnace and temperatures were taken by a Hoskins thermoelectric pyrometer inserted in the specimen. The shearing energy was determined by the change in speed of the flywheel. The results are shown in Figs. 1 and 2.

Ventilation A1-20 Tests of Siphoning Ventilators. A series of comparative tests have been conducted by A. A. Potter, J. P. Calderwood and A. J. Mack, of the Engineering Experiment Station, Kansas State Agricultural College, to study the effectiveness of ventilators. The results of these tests are shown in Table 1.

All ventilators used in the tests were 10-in. Ventilators No. 1 and 2 were of the siphoning type (see Fig. 3), the wind velocity being utilized to create an additional current of air through the ejector tube. No. 3 ventilator was not intended to produce any siphoning effect.

A wind tunnel 26 in. square and 15 ft. long was utilized. A variable-speed fan was inserted in one end of the tunnel capable of reproducing wind velocities up to 15 miles per hour. The ventilator to be tested was placed in the other end of the tunnel. A 10-in. pipe extending through the bottom of the tunnel was inserted to receive the various ventilators.

In performing the test, a ventilator was inserted in the tunnel and the fan regulated to produce the proper conditions. The velocity of the air in the tunnel and that induced through the ventilator was measured by means of an anemometer.

During the test each ventilator was subjected to as nearly as possible the same condition. The speed of the fan being regulated to secure the desired result. The velocity of the air passing over the ventilator and that siphoned through the tunnel when no ventilator was inserted would induce a current of air through the uncovered pipe leading into the tunnel, this data was recorded and is referred to in Table 1 under the head "No Ventilator."

In deducing any conclusions from these results it should be remembered that under actual conditions the ventilator action would be more pronounced. The tests, however, are of value in that each ventilator was subjected to similar conditions and the results show their comparative value.

The increase in velocity of the air in the ventilator above that produced when no ventilator was used gives a direct measure of the siphoning action. No. 3 ventilator shows actually a retarding of the air in passing through the ventilator, while Nos. 1 and 2 ventilators show a decided siphon action.

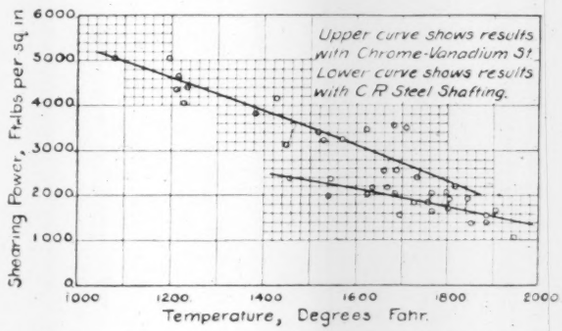

Upper curve shows results with Chrome-Vanadium St.
Lower curve shows results with C R Steel Shafting.
Shearing Power, Ft-lbs per sq. in.
Temperature, Degrees Fahr.

FIG. 1 ENERGY REQUIRED TO SHEAR STEEL AT HIGH TEMPERATURES WITH A ROTARY SHEAR

Ventilator No. 1 was at a slight disadvantage in these tests as it was larger in size than the other ventilators tested, and consequently obstructed the tunnel to a greater extent. This created a larger air pressure near the ventilator, increasing the tendency for the air to pass downward reducing the siphoning effect.

Address Director, Engineering Experiment Station, Kansas State Agricultural College, Manhattan, Kan.

Water, Sewage and Sanitation A1-20 The Bureau of Mines has recently received a report on the Collection and Examination of Rock Dust in Mine Air. This method consists in drawing air through a glass tube containing a layer of sized granulated sugar which filters the dust particles, using a calibrated air pump to measure the air. The sugar is then dissolved in distilled water, leaving the undissolved matter for examination. The sugar is submitted to an examination for insoluble matter before using it in the sampling tubes.

After dissolving the sugar a dust count is made from 1 cc. of the solution which has been made up to about 500 cc. by distilled water. The work was done by W. A. Selvig, F. D. Osgood and A. C. Fieldner, Bureau of Mines, Washington, D. C. Address F. G. Cottrell, Director.

Water, Sewage and Sanitation A2-20 Sulphur Dioxide as a Factor in the Smoke Problem of Salt Lake City. G. St. John Perrott has recently made a report to the Bureau of Mines on the sulphur dioxide contained in the atmosphere at Salt Lake City. The results show that the concentration is at no time to be an important factor in polluting the atmosphere and that most of the sulphur dioxide comes from the combustion of fuel in the city. At 12 noon the concentration is 0.1 part per million, while the greatest concentration occurs before 10 a. m. The concentration is higher on smoky days than on clear days and it decreases with the wind. The average concentration in December and January was about 0.15 part per million, while in March it was 0.01 part per million. Six parts per million have been observed in London, 0.6 part in Berlin and 1.8 parts in San Francisco. Samples taken by an airplane at 3000 ft. elevation, 2000 ft. elevation and 1000 ft. elevation showed a trace of sulphur dioxide. Bureau of Mines, Washington, D. C. Address F. G. Cottrell, Director.

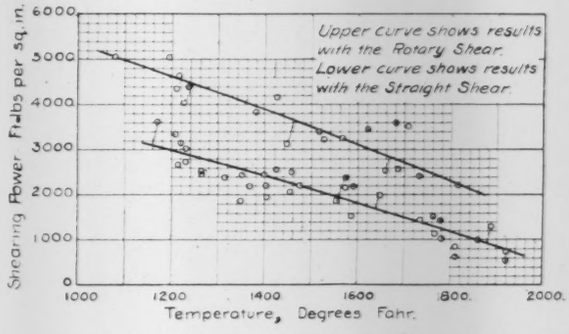

Upper curve shows results with the Rotary Shear.
Lower curve shows results with the Straight Shear.
Shearing Power Ft-lbs per sq. in.
Temperature, Degrees Fahr.

FIG. 2 ENERGY REQUIRED TO SHEAR CHROME-VANADIUM STEEL AT HIGH TEMPERATURE WITH ROTARY AND STRAIGHT SHEARS

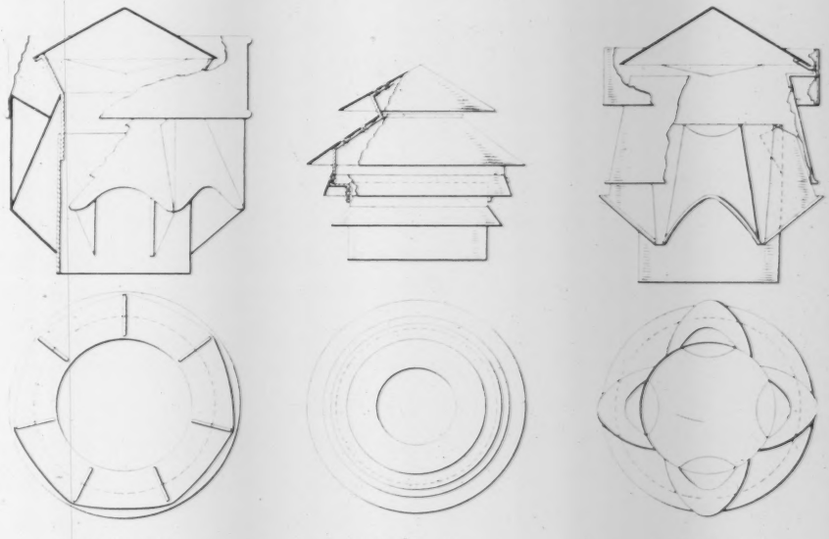


FIG. 3 TYPES OF VENTILATORS TESTED

TABLE 1 RESULTS OF TESTS ON VENTILATORS AT THE ENGINEERING EXPERIMENT STATION, KANSAS STATE AGRICULTURAL COLLEGE

Velocity of air, miles per hour	Velocity of Air in Ventilators in Feet Per Minute			
	No ventilator.	Ventilator No. 1.	Ventilator No. 2.	Ventilator No. 3.
1	26	35	30	17
2	55	70	61	36
3	85	106	93	55
4	112	143	123	73
5	140	178	153	90
6	168	213	183	107
7	197	250	213	126
8	224	286	244	144
9	252	319	274	162
10	280	235	305	179

Wood Products A7-20 Preservation. Light creosote oils properly injected into wood will prevent decay until the wood wears out or until it checks so badly that untreated portions are exposed. The heavier creosote oils used 25 or 50 years ago gave similar results. Forest Products Laboratory, Madison, Wis. Address Director.

Wood Products A8-20 Drying Periods. Table 2 gives the approximate time for kiln drying under mild conditions of 1-in. boards in green condition and partially air-dried to reduce the moisture content to 6 per cent of the weight of the dry wood. For stock greater than 1 in. and not more than 3 in. in thickness the drying time is proportional to the thickness. Quarter-sawed stock requires from 25 to 35 per cent more time. If the drying is carried on to 10 or 14 per cent instead of 6 per cent, the time is reduced to 1-4 or 1-3 less than before.

Address Director, Forest Products Laboratory, Madison, Wis.

B—RESEARCH IN PROGRESS

The purpose of this section of Engineering Research is to bring together those who are working on the same problem for cooperation or conference, to prevent unnecessary duplication of work

TABLE 2 APPROXIMATE TIME REQUIRED TO KILN-DRY, UNDER MILD CONDITIONS, 1-IN. PLAIN SAWED STOCK TO MOISTURE CONTENT OF 6 PER CENT, BASED ON WEIGHT OF DRY WOOD

Species	Days drying time	
	Green from the saw	Partially air-dry (25 per cent moisture content)
HARDWOODS:		
Swamp oak	45 to 50	20 to 25
Northern oak	30 to 40	17 to 20
Walnut, cherry	22 to 30	13 to 15
Mahogany, beech	16 to 22	9 to 12
Tupelo, gum	20 to 26	10 to 14
Birch, ash, sycamore	15 to 21	9 to 12
Poplar, basswood, chestnut, butternut, elm, cherry	8 to 10	4 to 6
Maple, hickory	17 to 23	9 to 13
CONIFERS:		
Western larch	9 to 12	4 to 6
Cypress, redwood	10 to 18	6 to 8
Douglas fir, yellow pine, incense cedar, spruce	4 to 6	3 to 4

and to inform the profession of the investigators who are engaged upon research problems. The addresses of these investigators are given for the purpose of correspondence.

Fuels, Gas, Tar and Coke B2-20 Volatility of Motor Fuels. An investigation to determine by vapor-tension apparatus the minimum temperature to establish a stable mixture of air and gasoline vapor in combining proportions. Address Frank A. Howard, Standard Oil Company, 26 Broadway, N. Y.

Fuels, Gas, Tar and Coke B3-20 Crushed Fuel. A new method of burning crushed fuel is being developed at Purdue University. Fuel is introduced after crushing to small-size grains through tuyeres at one side of a circular hearth. The coal is introduced by means of an air current through a fan blower, additional air for combustion being introduced by side openings. High capacity has been obtained with ease of control and regulation. The cost of operation is much less than that of the pulverized-coal methods. Address Professor G. A. Young, Purdue University, Lafayette, Ind.

Heat B5-20 The Heat Transmission of Cork and Lith Board. A series of experiments in preparation for the winter meeting of the Society. Address Prof. J. P. Calderwood, Kansas State Agricultural College, Manhattan, Kan.

Internal-Combustion Motors B6-20 Condition of Air Flow Through Radiators. Investigations on the condition of air flow through airplane cooling radiators. Twenty-four specimens have been tested so far. The problem of direct cooling of the engine is being studied and progress is also being made in determining the temperature distribution in the air cells of certain cooling radiators. A comprehensive technical paper is being prepared. Address Dr. S. W. Stratton, Bureau of Standards, Washington, D. C.

Internal-Combustion Motors B7-20 Carburetion of Fuels. Determination of the effect on the power and thermal efficiency of a tractor engine of varying the temperature of the fuel and air as it enters the carburetor. Quite elaborate apparatus is used to determine the temperature and pressure in the whole fuel intake system and to maintain exactly the conditions desired. Address C. W. Good, Department of Mechanical Engineering, University of Michigan, Ann Arbor, Mich., or Asst. Prof. W. E. Lay, Charge of Automobile Engineering, University of Michigan, Ann Arbor, Mich.

Steam Power B2-20 Corrosion of Steam Pipes. An investigation of the corrosion of steam pipes at Iowa State College. Results so far seem to indicate the presence of CO_2 as the cause of corrosion. Address Prof. M. P. Cleghorn, Iowa State College, Ames, Ia.

C—Research Problems

The purpose of this section of Engineering Research is to bring together persons who desire coöperation in research work or to bring together those who have problems and no equipment with those who are equipped to carry on research. It is hoped that those desiring coöperation or aid will state problems for publication in this section.

D—Research Equipment

The purpose of this section of Engineering Research is to give in concise form notes regarding the equipment of laboratories for mutual information and for the purpose of informing the profession of the equipment in various laboratories so that persons desiring special investigations may know where such work may be done.

Pennsylvania College D1-20 The Department of Mechanical and Electrical Engineering of Pennsylvania College, Gettysburg, Pa., has the following equipment:

One Riehlé 100,000-lb. testing machine.
One Riehlé 1000-lb. cement-testing machine.
One gage tester
Miscellaneous electrical and mechanical equipment.

E—Research Personal

The purpose of this section of Engineering Research is to give notes of a personal nature regarding the personnel of various laboratories, methods of procedure for commercial work or notes regarding the conduct of various laboratories.

F—Bibliographies

The purpose of this section of Engineering Research is to inform the profession of bibliographies which have been prepared. In general this work is done at the expense of the Society. Extensive bibliographies require the approval of the Research Committee. All bibliographies are loaned for a period of one month only. Additional copies are available, however, for periods of two weeks to members of the A.S.M.E. or to others recommended by members of the A.S.M.E. These bibliographies are on file in the offices of the Society.

Fuels, Gas, Tar and Coke F5-20 Fuel Oil. A bibliography of one page. Address A.S.M.E., 29 West 39th St., New York.

Internal-Combustion Motors F1-20 Spark Plugs. A bibliography of one page. Address A.S.M.E., 29 West 39th St., New York.

Petroleum, Asphalt and Wood Products F3-20 Petroleum and Allied Substances. The Bureau of Mines has compiled by E. H. Burroughs a list of recent articles on petroleum and allied substances. This bibliography is prepared each month. Address Bureau of Mines, Washington, D. C., F. G. Cottrell, Director.

Petroleum, Asphalt and Wood Products F4-20 The Natural Hydrocarbons such as gilsonite, elaterite, wurtzilite, grahamite, ozokerite and others by Raymond B. Ladoo, Mineral Technologist, Bureau of Mines. One-page bibliography of 22 items. Address Bureau of Mines, Washington, D. C., or A.S.M.E., 29 West 39th St., N. Y.

Water, Sewage and Sanitation F3-20 Process used in U. S. for Treatment and Filtration of Sewage Waters. A bibliography of three pages. Search 2955. Address A.S.M.E., 29 West 39th St., New York.

WORK OF THE A. S. M. E. BOILER CODE COMMITTEE

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in MECHANICAL ENGINEERING, in order that any one interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee in Cases Nos. 299 to 306 inclusive, as formulated at the meeting of May 24, 1920, and approved by the Council. In accordance with the Committee's practice, the names of inquirers have been omitted.

CASE NO. 299

Inquiry: In using Par. 212 to determine the maximum allowable internal working pressure that may be allowed on a staybolted surface under the Code Rules, it is stated that the weakening effect produced by drilling the staybolt holes must be considered. Cylindrical surfaces of the character referred to in this paragraph usually contain a riveted joint that weakens the structure more than does the drilling of staybolt holes. Should not the weakening effect of such joints be considered in the applying Par. 212?

Reply: Where the curved staybolted surface referred to in Par. 212 contains a riveted longitudinal joint or other construction except hand-holes, and the strength of the surface through such joint or other construction is less than through any line of staybolt holes in the same direction, the weakening effect of the joint or other construction instead of that produced by the drilling of the staybolt holes, is to be considered in making the calculations for pressure by this paragraph.

CASE NO. 300 (Annulled)

CASE NO. 301

Inquiry: Is it the intent of the Boiler Code under Par. 182 that the back pitch of tubes and rivets on drums which have a relatively high ratio of shell thickness to diameter of drum, shall be measured on the inside surface, the outside surface, or the median line of the shell?

Reply: It is the opinion of the Committee that in measuring the back pitch of tube holes or rivets, the measurements should be made on the flat plate before rolling, so that in checking up these measurements after construction, the result would correspond to the dimensions on the median line, or the mean of the measurements on the outside and inside surfaces.

CASE NO. 302

Inquiry: Is it the intent of Par. 278 of the Boiler Code which requires a full-sized direct connection to the boiler for each safety valve, that the exact meaning of this term shall be applied to small brass pop safety valves with male inlet connections: It is impossible to maintain the nominal threads on the inlet of these valves if the inlet opening is maintained full-sized in a male connection.

Reply: It is the opinion of the Committee that the rule given in Par. 278 of the Code applies to the connection leading to the safety valve and not to the safety valve itself. There need not be a full-sized opening through the valve itself, as the stamping of the capacity thereon by the manufacturer indicates in any case what is actually guaranteed for the valve by the maker.

CASE NO. 303

Inquiry: Is it the intent of the Boiler Code Committee in its references to commercial lap-welded pipe in Case No. 218 that the weld therein may be considered as conforming to the requirements for welded joints in Par. 186 of the Boiler Code?

Reply: For calculations of the maximum allowable working pressures to be permitted in open-hearth lap-welded pipe used in connection with boilers, it is the opinion of the Committee that the weld may be assumed as meeting the requirements of Par. 186.

CASE NO. 304

Inquiry: What amount of cooling and shrinking under pressure is necessary in the driving of rivets under the requirements of Par. 256 of the Boiler Code? Is it consistent with the intent of this paragraph to release the pressure while the rivet shows any degree of heat redness in color?

Reply: It is the opinion of the Committee that the pressure should be maintained upon the rivet after it is driven until no part of the head shows red in daylight.

CASE NO. 305
(In the hands of the Committee)

CASE NO. 306

Inquiry: Is it the intent of Par. 20 that the minimum thicknesses of tube sheets there specified for h.r.t. boilers is applicable also to vertical fire tube boilers and to locomotive type boilers?

Reply: It is the opinion of the Committee that while this paragraph refers specifically to h.r.t. boilers, it is equally applicable to boilers of the vertical fire tube and of the locomotive types, and its application to these two latter types is recommended by the Committee.

Have Engineers the Right to Prepare Legal Papers?

The New York Court of Appeals recently handed down an opinion which seemed to restrict the drawing of legal documents to persons possessing the right to practice law. This raised question in the minds of some engineers as to whether engineers and architects could continue in New York State to prepare contracts and certain other legal or semi-legal documents as has hitherto been their practice. It is the opinion of one legal authority, however, that engineers having special knowledge of the engineering work required and the professional skill enabling them to express it are not precluded as an incident in the practice of their profession from preparing "contracts for engineering work as has been the common practice for years." By so doing they are not holding themselves out as practicing law and are not practicing law.

The decision rendered by the Court of Appeals, Judge Crane writing the opinion, is that of People vs. Alfani (227 N. Y., p. 334). In that case there was evidence, as the chief judge said, "consisting of defendant's sign and repeated acts which permitted the trial court to find that the defendant held himself out to the public as being entitled to and did practice law." Defendant had a sign up advertising himself as a notary public and as a person drawing "all legal papers." The evidence showed that he did draw a bill of sale and chattel mortgage and advised as to the necessity of filing the mortgage in the county clerk's office and that he charged and received $4 therefor. When the client was leaving he inquired of the defendant, "In case I have any trouble of any kind and I need any legal advice, can I come back to you?" to which the defendant replied, "Yes."

In People vs. Title Guarantee & Trust Co. (227 N. Y., p. 366) a similar question arose in the prosecution against the trust company for drawing deeds and similar instruments in connection with their business of insuring titles to real estate, and the court held that such action did not violate the statute. The court says:

> We know that in cities constantly men engaged in the real-estate business and banks have prepared for their customers such instruments without doubt or criticism.
>
> The legislature when it enacted not only Section 280 of the Penal Law, which we have been considering, but also Section 270 relating to the practice of law by an individual without being admitted and registered, was charged with the same knowledge of prevailing customs and practices with which we are chargeable. Its members knew, oftentimes doubtless by practical and personal observation and experience, that laymen throughout the state were rendering such services as are here involved. Not only by practice and custom, but by inherent privilege they had the right to do this unless forbidden by statute, and if the legislature intended to prohibit a widespread practice and establish a new rule, it was its duty to say so clearly and unmistakably in the statute relating to the practice of law and rendition of legal services by individuals. It did not say so, and in my opinion there is not to be found in that section of the Penal Law any provision against the rendition of such services by an individual. We think the same idea is emphasized as in Section 280, that an individual who is not admitted to practice must not assume the character of an attorney at law. He is forbidden to practice or appear "as an attorney at law or as an attorney and counselor at law" or to make it a business to practice "as an attorney at law or an attorney and counselor at law" or to hold himself out to the public as being entitled "to practice law as aforesaid or in any other manner" or "to assume to be an attorney or counselor at law." But there is nothing which can fairly be regarded as indicating an intention to abolish an existing and widespread practice and to prevent a layman as such and without any simulation of or pretense to the character of an attorney from drawing a simple instrument as instructed by his customer and not involving or predicated upon any legal advice then given.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Department of MECHANICAL ENGINEERING are solicited. Contributions particularly welcomed are discussions of papers published in this Journal, brief articles of current interest to mechanical engineers, or suggestions from members of The American Society of Mechanical Engineers as to a better conduct of A. S. M. E. affairs.

Announcement

The Publication and Papers Committee of The American Society of Mechanical Engineers desires to afford members of the Society every opportunity to express themselves on the conduct of the Society and on other matters related to its affairs. Owing to the infrequency of meetings, communications to the editor of MECHANICAL ENGINEERING seem to offer the most prompt and direct means of placing the views of individuals before the entire membership. The Committee desires to encourage the writing of such communications as one evidence of the interest of the members.

Having in mind the reasonable limitation of space it is the intention to publish all such communications submitted. Where the communication cannot be published in full the author's name and address with a quoted sentence or a synopsis giving the purport of the letter will be published. It will be assumed that members will write in a terse and considerate style appropriate to our publications.—EDITOR.

Federated American Engineering Societies

TO THE EDITOR:

To be successful the Federated American Engineering Societies must be an instrument of service. Any engineering society that approaches the question from any other point of view is bound to be both disappointed and destructive. Manifold benefits will surely be derived by the member societies, but they are merely the rewards of service.

There is so much to be done for the public weal that only engineers can do that there can be no choice for you and me as to our participation or non-participation in the Federation. If we include ourselves among the "recreated engineers" of the present it all comes down to a question of choosing the most effective instrument of service. The world's experience amply shows that there is only one such instrument—union.

The reputation for indifference to and ineffectiveness in public affairs long since achieved by engineers is not of their deliberate choosing. Their aggregate effort is probably as great as that of many other professional classes. The principal difference lies in the fact that the engineers' efforts have usually been "out of phase." The Federated American Engineering Societies is essentially a synchronizer.

Many engineering societies will find that the constitution now drawn up will not conform to their ideas in all respects. No set of men is wise enough to draw up an instrument that will find universal approval. Let those who raise objections remember (*a*) how easy it is to object; (*b*) how easy it is to let petty complaints divert the mind from the master principle. This is a time for getting together. If we wait for a perfect constitution we shall always remain apart. Besides, a bad constitution will reveal itself in operation, and the cure is plain.

Some local societies think that in the Federation idea lies loss of identity. Let us not forget that there are two kinds of identity, one of which is "gladly lost." As for the other, it is strengthened by broad association, guidance and sustenance. No one has observed that the suckling child loses its identity, nor the adult who in his temporary weakness is revived by a blood transfusion.

To the Joint Conference Committee it may be said that adverse action by many of the societies should not be considered as a defeat of the project. There will be many societies which genuinely cannot adopt the plan without reservations in certain relatively small respects. If such reservations do not lessen the responsibility of such societies to the Federation then they should be counted among the members and the necessary adjustments can be made by the new organization at its leisure.

M. O. LEIGHTON,
National Service Representative,
Engineering Council.

Washington, D. C.

Select Strong Men for Directors of the New Federation!

TO THE EDITOR:

If an engineer believes that his profession should take an active part in public affairs and that it should organize effectively to protect its own interests, then he should lose no opportunity to urge general approval of the plans for the new Federation of Engineering Societies to be known as the American Engineering Council, which were presented at the Washington conference of engineers held on June 4 and 5.

Criticism of the machinery of the new organization is no longer pertinent or helpful. Nor is the detail of the machinery anyway quite so important as has been sometimes claimed.

The question of greatest importance is: How and by whom is this new machinery to be operated? What the new American Engineering Council is able to accomplish for the benefit of the profession and the public will depend very much on the quality of the thirty-odd engineers who are to be members of what may be called the Board of Directors of the profession.

Will the members of the local engineering societies and of the national societies take a live interest in the selection of the delegates who are to make up this new body? Will they use their influence to have men chosen who are able and willing to make the personal sacrifices of time and money necessary to attend the meetings of the Council, and who have in addition the ability and breadth of mind to enable them to judge wisely in all matters submitted to them?

It is upon the answers to such questions as this that the success or failure of the new plan for cooperative effort by various branches of the engineering profession will turn.

The experience gained in the operation of the present Engineering Council during the three years since its establishment has proved that there is real and important work to be done. It is work that demands time, energy and ability. It requires no small outlay of money, which the profession must furnish; but the profession must see to it also that men are selected for this position not because of a desire to honor some personal friend, but solely because the voters know the candidate chosen to be competent for the job and willing to faithfully discharge its obligations if elected.

CHARLES WHITING BAKER.

New York, N. Y.

Machine Tools—What Are They?

TO THE EDITOR:

At a meeting of The American Society of Mechanical Engineers in 1885 one of the subjects for discussion was the power requirements for machine tools. In the course of this discussion one of the speakers, complaining about the indefiniteness of the question, said, "What a machine tool is, is slightly in doubt," and this question has been with us ever since. The dictionaries define it

as a machine that uses tools, and the Custom House officials have accepted this and include woodworking tools under this classification. Users, dealers and manufacturers, however, do not accept the definition and the whole subject is as far from being settled as it was in 1885.

The question of the proper use of any word proceeds along lines of advocacy of certain use by various men, based on derivation, literal interpretation, or ancient authority; while the general acceptance of these words by those who have frequent occasion to use them is the actual test of their proper use. "Whatever is, is right," is sound etymological doctrine.

Edward H. Knight in his mechanical dictionary, published in 1872, gives the following definitions:

Machine: An instrument of lower grade than an engine, its motor being separate. It is distinct from a tool, as it contains within itself its own guide for operation.

Machine Tool: A machine in which the tool is directed by guides and automatic appliances. Among tools (sic) of this class for metals are lathes, punches and shears. Machine tools for wood are sawing machines, planing machines, etc.

It is the habit of dictionary makers to copy each other, and it is not improbable that our present-day dictionary interpretation of the word is derived from the above. It must also be said that to define a machine tool as a tool-using machine is a very natural and obvious definition to give. There is some doubt, however, if the original and common use of the words is as indicated above.

Mr. Cameron Knight, author of The Mechanician and Constructor, published in 1869, in the course of a very complete definition of shop terms, includes the following:

Tools include every implement small and large, simple or complex, which is used to produce or operate upon the work in the course of progress. A center punch in a turner's pocket is a tool, and the lathe before him is a tool.

It is an easily verified fact that in the text and advertising columns of the early mechanical papers such as the *Scientific American* (1846), the *Mechanics' Magazine* (1836), and the *American Artizan* (1862), the term "machine tools" is used but seldom, and then exclusively by editorial writers. The first observed use was in 1862. "Tools" is the word that was in universal use during the Civil War period to indicate what we now call machine tools. Advertisements for the sale of the after-war surplus were either under this caption or under the heading "machinist's tools." This use of the word persists into the eighties. In fact, in the discussion referred to in the opening paragraph, the word "tools" was not infrequently used. There can be no reasonable doubt, therefore, that although the expression "machine tools" was at least recognized as far back as 1860, "tools" was the word in common and everyday use until the eighties.

In 1879, Frederic B. Miles formed a company with the name "Machine Tool Works." This is the first noted instance of the use of this term by a shop man. The above company advertised the manufacture of steam hammers, planing machines, and lathes.

On first thought we may be inclined to define a machinist as a machine-using workman, and a machine shop as machine-using shop, but this definition will admit weavers and textile mills to these classifications. It is evident that a machinist is a machine-*building* workman, and a machine shop is a shop that builds machinery. By an analogous reasoning a machine tool is not a tool-using machine, but a machine-building tool; that is, a tool or machine for building machinery. This definition conforms to the best modern definition of the term, viz.: Machine tools are machines which, when taken as a group, will reproduce themselves. This excellent definition has the disadvantage of being general rather than specific, and as a secondary definition I would suggest the following: A machine tool is any metal-working tool whose waste is in the form of chips. This is specific and can be easily applied to any particular machine. It is not necessary to define a metal "chip," but it may be advisable to recall that the sparks from a grinding machine are chips, very small chips to be sure, but chips. This definition excludes sheet-metal-working machinery and metal-forming and forging machines, but these are probably not classed as machine tools by a majority of shop men, and in any case it is necessary to draw the line somewhere, and this seems to be the best place.

This classification will then include all metal-cutting machinery whose action is a progressive cutting away of surplus stock, a gradual reduction in size until the finished dimensions are reached. A considerable part of such machines use a single-point cutting tool, and in these cases as well as the case of milling cutters the angles of these cutting tools are of common interest to machinists and machine-tool builders. The design of these machines has progressed along similar lines and the introduction of single-pulley drives with all-geared feeds and speeds has found ready acceptance among manufacturers. Lathes, milling machines, grinders, drills, boring machines, etc., are now so equipped.

A press, when used for piercing sheet metal, has very little in common with any of the above-mentioned machines. They are all metal-cutting machines, and here the similarity ceases. The metal is not in the same form, and the cutting tools have nothing in common with other metal-cutting tools as to construction or cutting angles. When a press is used for forming it has nothing in common with lathes, etc., other than the fact that they are all metal-*working* machines, such as power hammers, bulldozers, swaging machines, etc.

If we admit that the terms "machine tools" and "metal-working machinery" are coextensive, or go further and define a machine tool as a tool-using machine, we are then confronted with the lack of any definite and restricted term to apply to 90 per cent of our machine-shop equipment. It seems desirable to have such a term, inasmuch as a steam hammer has no more in common with a lathe than a blacksmith has with a machinist. It is probably a fact that 90 per cent of those who are variously engaged in the machine-tool industry will say that a universal grinding machine is a machine tool, but would not be quite as sure about a punch press, a steam hammer or a mowing machine, and this great majority of opinion should be the deciding element in this question of terminology.

L. L. THWING.

Boston, Mass.

Fiber Stress in a Square Plate

TO THE EDITOR:

In your April issue p. 249, H. W. Sibert gives a method for finding the fiber stress in a square plate supported on the edges and loaded with a uniform load normal to its surface. I believe his method of finding this stress is incorrect, and that therefore his results are incorrect. He finds a bending moment of constant intensity in a direction at right angles to a rectangular axis through the center of the plate and equal fiber stress in that direction from center of plate to the middle of a supporting edge. It is not possible for any stress to exist parallel with the support at any point along that support, for stress, of necessity, means a curving of the plate; and no curving could take place while the plate is in contact with its straight and rigid support.

It is further incorrect to combine these two rectangular stress intensities, as Mr. Sibert has done, by taking the square root of the sum of the squares, for the diagonal of the square on which the combined force acts is increased (over the side of the square) in exactly the same ratio, so that the intensity would remain exactly the same in a diagonal direction.

In my book "Concrete," p. 287, I have given a method for solving the problem which is practically correct and about as simple as it can be made. In that solution two rectangular strips are taken across the middle of the plate, each one unit wide. The load on the middle square unit is equally divided between these two strips, but other intersecting strips take less and less of the load w, because, as the edge is approached, these strips cannot bend and take their equal share of the load. The load on the critical strip is the full w per unit at the support, and the curve of increase from center to support is assumed to be a parabola. This gives $7wL^2$ 96 as the bending moment in the middle of the plate against Mr. Sibert's value of wL^2 16.

EDWARD GODFREY.

Pittsburgh, Pa.

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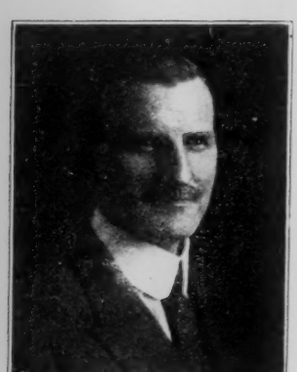
The Federated American Engineering Societies

Steps to Be Taken to Complete the Organization—Its Effects on the Work of Existing Local and National Societies



E. S. CARMAN, CHAIRMAN OF LOCAL SECTIONS COMMITTEE

THE Federated American Engineering Societies, organized in Washington June 3 and 4, marks one of the milestones in this, the engineering societies' epoch of organization.

It was apparent several years ago that in order for the engineering profession to continue to occupy a high rank in the catalog of professions, a means must be provided whereby all engineers, regardless of branch, could act together in considering matters of common interest to the profession at large and also to the public.

In the organization of the Federated American Engineering Societies the means has been provided. Therefore, without further statement as to the desirability of having such an organization, let us accept the facts as they are, viz., that the organization has been started, and that it is now more important to discuss what will be necessary to complete its organization and properly begin its activities in order that the Federation may be most effective in representing the interests of the engineers of the country.

The organizing conference at Washington placed in the hands of the Joint Conference Committee of the four Founder Societies and Engineering Council the *ad interim* authority until the organization should be fully completed. The next steps then to be taken are:

1 Consideration by local, state, regional and national societies and applications made for charter membership (all organizations invited to attend the Washington Conference are eligible) in the F. A. E. S.
2 Appointment of societies' representatives on American Engineering Council.
3 Conference of representatives to elect officers and complete organization.
4 Activities to be immediately begun by the officers and organization.

As an obligation which they owe to the profession, every engineering society in the United States should be fully acquainted with the constitution and by-laws of the F. A. E. S. and be prepared to make an early decision and become a charter member.

The effect that the F. A. E. S. will have on other societies, and how it will affect their present activities can best be summarized as follows:

Local Societies

1 Participation and expression in all national, state or regional affairs of interest to the engineering profession.
2. Assistance in local affairs (when desired) by the national organization.
3. Greater local activities by complete local affiliation of all local and national societies' local sections.

State Societies

1 Participation and expression in all national, state or regional affairs of interest to the engineering profession.
2 Assistance in state affairs by local, regional and national societies.
3 Uniform recommendation in the various states regarding license and registration laws, road building, public utilities, etc.

Regional Societies

1 An opportunity to assist local, state and national societies in matters of common interest.
2 Receive assistance from local, state and national societies in furthering matters of common interest.

National Societies

1 Provide a place through local affiliations where the individual members may meet and have an opportunity of expression in local, state and regional affairs.
2 Provide a means of further coöperation with all engineering societies and coördinating such activities as
   Standardization
   Research
   Education
   Ethics
   Legislation
   National public engineering projects.
3 A more complete coöperation between the several national societies.

The question as to whether or not the engineer desires to have a part in local, state and national public affairs is answered today in the affirmative, as we now find him so engaged. He has accepted his local citizenship responsibilities and is now desirous of having a means of expression in exercising his national citizenship obligations.

The engineer today is alert and aggressive and eager to accept the responsibility that comes with the greater activities.

The F. A. E. S., as stated before, is only a beginning of society coöperation and of necessity must proceed cautiously and yet effectively.

Is it too much to expect that as the years come and go and complete confidence has been established by successful performance, the final result will be: One large, all-inclusive American Engineering Society with national professional branches and organizations, local branches and clubs in all of the many cities, and only one payment of dues by the members to entitle them to all privileges of local, state, regional and national organizations?

E. S. CARMAN,
A. S. M. E. Representative,
Joint Conference Committee.

Cleveland, Ohio.

Wage Increases Not Necessarily on a Straight-Line Curve

Early this summer Mr. Charles Piez, Mem. Am. Soc. M. E., submitted to the United States Railroad Labor Board, for the Board of Directors of the Illinois Manufacturers' Association, a statement of principles which he believed should prevail in deciding upon wage increases. "The practice," he says, "of basing wages on the cost of living, without taking into account the work performed for the wages is, in our opinion at the very bottom of the present disturbed and unsatisfactory labor condition. . . . If we accept the figures submitted that $1700 represents the lowest subsistence level and $2500 the lowest comfort level for an American family, and base the scale of wages in the transportation service on the assumption that every man engaged in this service, no matter where he lives, whether married or single, is entitled to a wage based on a scale with those figures as minimums, would it not be fair to assume that every wage earner in every character of employment everywhere in this country is entitled to a scale based on that same minimum?"

Mr. Piez contends that if such a universal demand were made and acceded to, based on a straight time basis rather than on a production basis, the farms, the mines and the industries would be wholly unable to meet the cost. "Wages can't be paid unless they are earned and we can't get out of the common pot more than we put into it."

He further says there is undoubtedly justice in the demand for an increase among railroad workers and that there is no intention of arguing against a fair increase; and that particularly there should be an increase among the lower-paid classes as the high cost of living has affected them the most adversely. Nevertheless, "The divorce of wages from production has been one of the calamities of the war, for it has created in the mind of the wage earner the delusion that irrespective of output, performance, or character of service rendered, he is entitled to live on a certain scale. Statisticians spend their time in developing elaborated lists of family requirements, instead of determining how wage increase based on these requirements can be paid.

"And so it happens that during the most critical time in the industrial history of the country, when the consumption of commodities has expanded, and world production of commodities has been greatly impaired, we have established a shorter working day, have abolished piece and premium forms of payment, and have imbued the wage earner with the idea that he is entitled to a good living if he but spends eight hours at a job."

Two Attitudes on The Department of Public Works

As a member of the National Chamber of Commerce, Engineering Council was instrumental in that having that body present to its member organizations a ballot designed to record the attitude of the Chamber on the question as to whether or not a Department of Public Works should be brought into being.

The propositions, which were submitted to 478 organizations, and the results of the balloting on each were as follows:

1 Shall a Department of Public Works be established by the national government?—827½ votes in favor—549½ votes opposed.

2 Shall a Department of Public Works be established by a suitable modification of the existing Department of the Interior, excluding therefrom the non-related bureaus and offices and by change of name from Department of the Interior to Department of Public Works?—676½ votes in favor—639½ votes opposed.

3 Shall a Department of Public Works be established by creation of an entirely new department?—283 votes in favor—993 votes opposed.

In accordance with these votes, the Chamber is not committed to either the first or the second proposition, for the reason that two-thirds of the votes cast were not in favor of either. As to the third proposition, the Chamber is placed by the voting in a position of opposition; for more than one-third of the total voting strength of the Chamber was recorded and more than two-thirds of the votes thus cast, representing more than twenty states, were recorded in opposition.

In this connection it is gratifying to note the interest of men of affairs in this movement as reflected in one of the planks of the Republican platform. As this plank was initiated and brought about by engineers to its present degree of acceptability it will be of interest to quote its phraseology:

> We advocate a thorough investigation of the present organization of the Federal departments and bureaus with a view to securing consolidation, a more businesslike distribution of functions, the elimination of duplication, delays and overlapping of work and the establishment of an up-to-date and efficient administrative organization.

It is further understood in Washington that the Smoot-Reavis bill proposing a general reorganization of all departments along the lines suggested by the engineers for the Department of Public Works carries the provision that the first department to be so reorganized will be the Department of the Interior and its conversion to a Department of Public Works.

The Outdoor Power Plant

In the May issue of MECHANICAL ENGINEERING, p. 307, reference was made to an article on the practicability of the outdoor generating station, written by H. W. Buck, and published in the *General Electric Review* of March, in which the advantages of such construction were pointed out. There has now appeared in the May number of that review an article by Henry G. Reist, Mem. Am. Soc. M. E., calling attention to the difficulties to be encountered in the outdoor plant, one of the most serious of which is the necessity for the construction of the generators so that the windings will be kept dry and at the same time will be properly ventilated. He says:

> It has always been assumed that the windings of electric machines should be kept dry. It is difficult to maintain this condition and get proper ventilation in a generator exposed to the weather, without special construction and additional expense. If the generator is allowed to become cold when not in use there is likely to be condensation of moisture on coils under certain atmospheric conditions. To prevent this, many pieces of electric apparatus are provided with special heaters of some sort to keep the machine warm when it is idle.
>
> In case machines are exposed in very cold weather there is danger of difficulty from the oil becoming too thick. This danger would apply especially to self-oiling thrust bearings placed at the top of the machines, since these might heat at starting before the oil became sufficiently thin to circulate freely.
>
> Automatic stations, which operate without an attendant, should be inspected from time to time by a patrol. In case of very cold or disagreeable weather it is probable that such inspection would be superficial.
>
> On synchronous machines placed out of doors the installation of exciter units presents difficulties. In small machines exciters are frequently belted and on larger machines they are either direct-connected or driven by motors. Whatever arrangement is used, considerable inconvenience will be caused by lack of a protecting roof. In some installations these parts, together with the governing mechanism, can be placed in chambers in the masonry below the generator floor; but in other cases, due to danger from high water, this could not be done, and with small low-head machines such masonry construction would add considerably to the expense.
>
> I would suggest that instead of building special weatherproof out-of-door generators, standard generators be used, and that simple, inexpensive semi-portable shelters be erected over them. In the case of several machines in one installation, I think it would be desirable to have a low house extending over the line of machines, with a gantry crane bridging the house, the house, or at least its roof, to be made in sections which can be moved on a track parallel with the line of generators to telescope with the roof over the adjacent generator, or each generator to be covered with a unit roof which may be lifted bodily from its place by means of a crane. I believe there would be sufficient heat generated to keep such a power-house comfortable, and that by suitably arranging the ventilators warm air could be passed over any generator that was not in use, thus overcoming the difficulties which might be experienced with the generators out of doors.
>
> The simple house suggested would provide a shelter for the exciters, waterwheel governors, and the patrol on his visits, and would seem to offer all the advantages of a more expensive power house. It is probable that a protecting house, as described, could be constructed for little more than the extra cost of a generator exposed to the weather.

Across the Continent by Land and Air

The first transcontinental convoy of the Motor Transport Corps which crossed from Washington, D. C., to San Francisco, Cal., last summer has given, as shown in the paper presented by Lieut. E. R. Jackson, Mem.Am.Soc.M.E., at the Spring Meeting of The American Society of Mechanical Engineers, a large amount of valuable information both as to the state of the roads and as to the various makes of automotive equipment and methods of handling them.

It is gratifying to find that an earnest effort is being made to add to this store of knowledge. On June 14 the second transcontinental convoy left the East on its long, and at times weary and dangerous, journey to the Pacific coast, and we may expect to hear in a few months how the experience of last year helped on the present trip.

An interesting enterprise is now being carried out in another direction also. There were two long flights made last summer: one from Long Island to the Pacific and back, carried out in the form of a race, and the other, the "flight around the rim," which was intended as a test of endurance of machines and accessories. Both of these flights gave a considerable amount of valuable information and showed what can be done by the Army pilots.

This summer conditions have on the whole been less favorable to Army aeronautics, but an attempt is being made to carry out an all-air flight from Long Island to Nome, Alaska, which is of interest not only because of the great distance to be covered, but because in its final laps this flight will probably become a precursor of a regular system of communication by air which will bind more closely to this country a wealthy but somewhat neglected possession.

In this connection, attention may also be called to the vigorous extension of the net of aerial mail transportation by the Post Office Department, which has recently asked for bids for several new routes which will afford air delivery of mails to towns in the South and West.

Making Houses Truly Livable

Taking our living conditions all around, it would appear that while we may have progressed in some ways during the last 50 or 100 years, and have learned to keep our houses clean (improved sewerage), supplied with good water, and efficiently lighted, in other directions we have not made very much progress as compared with the houses of the times of the first white settlers on this continent.

It is generally recognized in anthropology that one of the greatest milestones in the development of the human race was passed when men learned to heat their houses. This is what made the habitation of the so-called moderate-climate zone possible, and it is there that most of the progress of the human race has been achieved.

The human race has not, however, passed the next stage of development in this direction, which is to make our houses and offices truly livable the year round. We have learned how to combat cold, but not how to handle heat,—at least we have not yet learned the wisdom of actually doing it.

One of the reasons why tropical countries are so hard on the white man as to make his development in those sections a very uncertain problem, is because a white man cannot live and preserve his efficiency year in and year out at a temperature above blood heat. Even in the so-called temperate zone we have conditions for several months in each year which very decidedly reduce the efficiency of our working forces and sometimes quite harmfully affect the health of our population.

If we are heating our houses in the winter, why, with our present knowledge of refrigeration, can we not cool them in the summer? As a matter of fact, this has already been done in numerous instances. Thus, a refrigerating plant was installed in the New York Stock Exchange a few years ago, with the result that a temperature of 65 deg. fahr. is maintained on the floor of the exchange no matter what may be the outside atmospheric temperature.

The development of the small automatic refrigerator for preserving perishable goods which works practically without requiring any attendance, bears an important promise for the future. And if automatic refrigeration can be installed to keep meat and butter fresh and clean at a cost of a few cents a day, there is no reason whatsoever why a similar but larger machine could not be installed to do the same service for human beings, who need a constant temperature to be in good condition just as much as perishable foods. This applies especially to places like hospitals, offices, etc.

At least two obstacles have in the past held back the general introduction of cooling systems. The first is the higher relative cost and expense of operation of a refrigerating plant compared with a heating system, which is offset in part, however, by the fact that the temperature range required in cooling is only about half that required in heating. The second is the difficulty of dealing with the humidity often present in the warm air and which, at reduced temperatures, becomes exceedingly uncomfortable. If the air is cooled its vapor is condensed, and unless proper care is taken it will collect on the cooler surfaces of a building. However, ways have already been found to deal with this side of the problem and no doubt other ways will be found as soon as an earnest effort is made to apply artificial house cooling on a wide scale.

Probably the chief and real obstacle to the general introduction of cooling systems in buildings has been the fact that people *can* get along without them by the use of such local expedients as electric fans or arrangements for the proper ventilation and circulation of air. People cannot get along without heating systems, however, and they accordingly have become universal and have reached their high state of efficiency.

The American public, at least, is accustomed to having the things it wants regardless of cost, as evidenced by the high percentage of the population who have secured automobiles within the period of a few years, and as the development of our buildings progresses in the matter of comfort and convenience, there will undoubtedly be a greater demand for the same degree of comfort during the warm weather as during the cold weather, and we may expect the mechanical engineer eventually to have a large and fertile field for his abilities in the design, construction and operation of small cooling systems, comparable in cost and size to our small heating systems.

Ten Ways to Kill a Branch of an Engineering Society

(1) Don't come to the meetings. (2) If you do come, come late. (3) If the weather doesn't suit you, don't think of coming. (4) If you do attend a meeting, find fault with the work of the officers and other members. (5) Never accept office, as it is easier to criticize than to do things. (6) Nevertheless, get sore if you are not appointed on the Committee, but if you are, do not attend Committee meetings. (7) If asked by the chairman to give your opinion on some matter, tell him you have nothing to say. After the meeting tell everyone how things ought to be done. (8) Do nothing more than is absolutely necessary, but when members roll up their sleeves and willingly, unselfishly use their ability to help matters along, howl that the branch is run by a clique. (9) Hold back your dues as long as possible, or don't pay at all. (10) Don't bother about getting new members. "Let George do it."—*The Engineering Institute of Canada.*

Listing Forms for Directory of Consulting Engineers in 1920 Volume of Condensed Catalogues

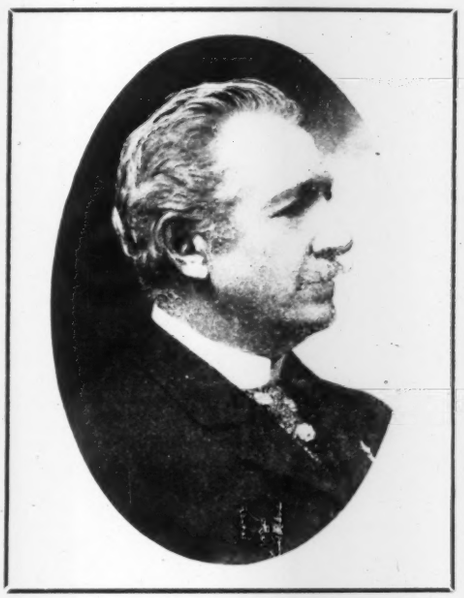
It is planned to further extend and improve the Directory of Consulting Engineers in the forthcoming issue of the Condensed Catalogues, and members actively engaged along consulting lines are invited to write to the Society for special forms covering listings in this section of the volume. In developing the Directory it is particularly desirable that all the specialized lines of practice should be indicated so far as possible, and the coöperation of the members to this end will be welcomed.

CHARLES ETHAN BILLINGS

Charles Ethan Billings, chairman of the Board of Directors and former president of the Billings & Spencer Manufacturing Co., Hartford, Conn., died on June 4, 1920, after a long illness.

Mr. Billings was born in Wethersfield, Vt., on December 5, 1835. After receiving a common-school education, he served a three-year apprenticeship in the gun department of the machine works of the Robbins & Lawrence Co., Windsor, Vt. In 1856 he entered the employ of Colt's Patent Firearms Manufacturing Co. as a toolmaker and die sinker. During the early stages of the Civil War he was employed in the gun factories of E. Remington & Sons, Ilion, N. Y.

From 1863 to the close of the war, Mr. Billings was making drop forgings for the U. S. Government. He was one of the



Charles Ethan Billings

first men in the country to use drop hammers in the manufacture of arms, and it was he who perfected the forgings that were universally used in the manufacture of pistols for many years afterward.

When the war was at its height and many large contracts for pistols were coming in from the Government, it was found necessary often to run the shops at night. The continual pounding of the drop hammers was a source of great disturbance to the surrounding neighbors and they voiced their indignation in no uncertain terms. It was not long before a delegation composed of the mayor and some prominent citizens waited upon Mr. Billings to complain of the noises that issued nightly from the shop and to demand that they cease. Mr. Billings stated briefly that he had orders to run his shop night and day until the contract was completed. "Orders," exclaimed the mayor, "Be pleased to understand, sir, that all orders in this town come from me. I should like to ask you, sir, who gave you these orders?" "My orders," replied Mr. Billings, "come from Abraham Lincoln." The noisy drop hammers continued their work until the peace of Appomattox.

At the close of the Civil War, Mr. Billings returned to Hartford where he became superintendent of the Weed Sewing Machine Co. for three years. In 1869 the Billings & Spencer Co. was organized, C. M. Spencer being the other member of the firm. The company was incorporated to manufacture drop forgings and develop various improvements and inventions in the numerous small parts of machinery which, through the inventive genuis of Mr. Billings, became of great value to the world. He was the inventor of a score of articles now in general use such as drills, chucks, pocket knives, wrenches, etc.

Mr. Billings was a life member of the Society, and one of the first to join the organization, which he did in 1880. He served as vice-president and president from 1893 to 1895.

He was also very active in the civic affairs of Hartford, where for twelve years he was president of the Board of Fire Commissioners. For several terms he served as councilman and as alderman. He was president of the State Savings Bank of Hartford and trustee of the Hartford Trust Co. He leaves a wife, two sons and one daughter.

The Technical Library As Related to Plant Efficiency

Never in the history of industry in the United States has so forceful an effort been directed toward the mental and physical elevation of the individual, with the ultimate purpose of greater and improved production through increased efficiency, as at the present time. Never has so much intensive attention been devoted to the fundamental and advanced training of executives and labor in general in industrial establishments as in these days when economic conditions demand a most comprehensive understanding of the technicalities that complex production. From president to apprentice, thorough knowledge of the task in hand is an absolute essential to the success of the industry. Even the unskilled laborer must be more than a machine performing routine work merely as routine, without intelligent comprehension of, and interest in, his labor.

Upon the uncontested premise that greater efficiency means increased and better production and that efficiency is the result of intelligent interest, study and knowledge, rests the claim that the industrial establishment which invests in the installation of a technical library within its plant, will soon outstrip its competitors who have not had the foresight to adopt the plan. The American Library Association, coöperating with the Special Libraries Association, two national organizations of high standing, plans under its enlarged program to provide estimates, outline the selection of books best suited to the industry, and explain the working system that will bring the best results.—in fact, to coöperate in every possible way with the concern which is to have the library installed.

"It is true," declared a famous university professor, "that knowledge is power, but the best kind of knowledge does not consist of knowing facts, but in knowing where to go and find facts when you need them."

The progressive executive knows the value of forwarding the mental and physical welfare of his employees and realizes that their condition is reflected in the condition of his industry. He knows that the higher the plane of the workman's intelligence, the worthier his output, and he adopts every feasible method of promoting that efficiency which is derived from mental advancement. He recognizes that by study the worker becomes more valuable to himself and to the concern, and he opens every possible avenue that leads to that end. Once the interest in serious, purposeful reading is awakened, it continues, the reader attains a higher position, his work is bettered and the general welfare of the industry enhanced.

It is therefore to the great advantage of the employer that the habit of reading and study be encouraged to the fullest extent, and to this end the technical library is the best possible coöperative agent. But the technical library is not designed for the benefit of the working forces alone. While it is a wonderful medium for the promotion of increased efficiency through study and comprehensive reading, it is the source, if properly conducted, of information for the executives as well. It is the fountain head to which they can turn for a solution of practically every problem that presents itself; it is the clearing house from which are available the minutest details of shop and office direction; it is the source of time- and money-saving knowledge, obviating the necessity of experimenting, with its waste of material, effort and financial outlay. It contains treatises on the most modern methods, the newest appliances and devices, system and management—in fact, the yield of the best brains of many persons for the instant use of the individual.

News and Notes of The Federated American Engineering Societies

Technical Club of Dallas Joins the New Organization

One of the outstanding features of the Organizing Conference was the enthusiastic interest of the delegates representing the local, state, and regional organizations. It is not surprising, therefore, that these local organizations should be among the first to apply for membership in The Federated American Engineering Societies. Already the Technical Club of Dallas has made application and in doing so filed its claim as being the first local organization to apply. It thus evidenced its enthusiastic desire to take an active part in the formation of the Federation. Congratulations to the Technical Club of Dallas.

Engineering Council Gives Its Endorsement to the Federation

At its last regular meeting held on July 17 Engineering Council passed resolutions endorsing the new Federated American Engineering Societies and offering its assistance in the conduct of the work necessary before the new organization can function. Inasmuch as the constitution of the Federation calls for the creation of an American Engineering Council with representatives from the various member societies, the action of the present Council is one of great importance, as to all practical purposes it means that the American Engineering Council is now functioning with six societies backing it. The resolutions of the Engineering Council follow:

Voted, That Engineering Council heartily endorse the plan of organization of The Federated American Engineering Societies and the American Engineering Council, adopted by the Organizing Conference of technical societies in Washington June 3 and 4, and authorize its Executive Committee to proffer and perform on the part of Council such assistance as may be practicable in completing the work of the Organizing Conference of the Joint Conference Committee of the Founder Societies in establishing the American Engineering Council.

Voted, That Engineering Council authorize its Executive Committee to deal with any question of coöperation with the Joint Conference Committee of the Founder Societies, relating to the permanent organization of The Federated American Engineering Societies, which may come up during the summer.

Voted, That the Secretary be instructed to invite to future meetings of Engineering Council delegates of the societies participating in the Organizing Conference in Washington, June 3 and 4, and editors of technical journals who may be interested.

Three More National Societies Favor the Federation

The last issue of MECHANICAL ENGINEERING carried the announcement that The American Society of Mechanical Engineers were the first to voice their intention to join the newly organized Federated American Engineering Societies. Since then three other national engineering societies have met in convention and favorably considered the question of also joining the new organization.

At the annual meeting of the American Institute of Chemical Engineers held in Montreal June 28th-July 3rd, the question of the Institute becoming a member of The Federated American Engineering Societies was discussed and referred to its Council for definite action at its meeting on July 25th.

The report of delegates to the Organizing Conference was read at the meeting of the Board of Direction of the American Institute of Electrical Engineers at the annual convention at White Sulphur Springs, W. Va., June 30 and the following resolution adopted:

RESOLVED: that it is the sense of this Board that the American Institute of Electrical Engineers should join The Federated American Engineering Societies, but that as there is a small attendance at this meeting and a new Board will be constituted, commencing with the administrative year on August 1, action be deferred until the August meeting of the Board and that a letter be sent to the members of the incoming Board, with a request that they give careful consideration to the matter and be prepared to act at the next meeting.

The report of the delegates to the Washington Organizing Conference was read at the meeting of the Board of Direction of the American Institute of Mining and Metallurgical Engineers on June 25, was favorably discussed and referred to the Finance Committee to devise and report on means for meeting the financial requirements.

The report of the delegates to the Washington Conference representing the American Society of Civil Engineers will be presented at the Annual Convention of that Society, at Portland, Ore., August 10-12, 1920.

Some Technical Press Comments on the Washington Conference

The youngest profession has voluntarily accepted its responsibility in human affairs and is now reaching forward to a career of essential service. This is unmistakably the meaning of the action of the organizing conference of engineers held in Washington, early last month. . . . the object of the Federated American Engineering Societies is to give expression to the exalted motive of service for the public good. It stands to the credit of the profession that this was done without a dissenting vote, although the forces of materialism were active and vigorous in expressing their opposition in debate.

Truly one of the great milestones in engineering history has been passed. From now on the youngest of the professions will begin to wield a power in public affairs which is destined to be a controlling factor in the working out of economic and industrial conditions.—*Industrial Management*, July, 1920.

Seldom does the habitué of technical and general gatherings absorb so many inspirational thoughts tumbling fast through a medium electrified with a sharp clash of intense purpose as at Washington last week. This alone would mark the recent organization of The Federated American Engineering Societies. Not only were the brief and pithy addresses from eminent engineers in various walks of life full of allusion to the widespread value of engineering thought and achievements, but even the sharpest discussion was based entirely upon the best and most effective method of giving service. Service was the keynote—not struck by the first speaker of the meeting and then forgotten, but animating the proceedings to the end.—*Chemical and Metallurgical Engineering*, June 9, 1920

This organization by engineers is one that will result in a large measure of good to the profession of engineering. It is a practical demonstration of views long and stoutly maintained by this journal and exactly in line with definite progress toward a closer and more valuable working association of engineers throughout the country.—*American Architect*, June 1920.

The greatest step, or at least the greatest potential step, in the history of engineering in the United States, was taken on June 3 and 4 at the Joint Engineering Conference in Washington when the Federated American Engineering Societies was organized. This body was created for the avowed purpose of public service. The American Electrical Railway Engineering Association should assume its full share of coöperation in the federated societies.—*Electrical Railway Journal*, July, 1920.

No gathering of engineers in America has ever quite equaled in potential importance that which took place at Washington, D. C., on June 3 and 4. With the entry into The Federated American Engineering Societies of the component organizations that are expected to support it, there would be 100,000 engineers banded together for public service and the advancement of the profession in the United States. It was intimated that the American Association of Engineers would continue to carry on in its own way. The outcome of this experiment in federation will be watched with the greatest interest by engineers in Canada. It is not unlikely that similar action will before long become a matter for serious consideration and discussion amongst technical men in this country.—*Canadian Engineer*, July 1, 1920.

The Federated Engineering Societies are to be congratulated on their recognition of the principle of publicity. When the engineering world shall speak out habitually and authoritatively through the professional and lay press alike, to recount its achievements, to outline its projects, and to tender its advice on all matters where it has

knowledge and a collective concern, it will both perform an imperative duty and help individual engineers to gain the great degree of recognition, the high scale of remuneration, and the broad sphere of influence that should be theirs.—*Electrical World*, June 19, 1920.

One of the most important meetings of engineers that has been held in the United States, assembled in Washington, June 3-4, to take up the question of forming a federation of the engineering societies of the country. The importance of this conference can hardly be overestimated. It has been said of engineers that they cannot coöperate, or at any rate they do not, and that this has been the reason why engineers have not had the influence and standing in the community to which the importance of their professional work entitles them.—*Power Plant Engineering*, July 1, 1920.

Organization of The Federated American Engineering Societies was effected at the organizing conference of national, local, state and regional engineering and allied technical organizations at the Cosmos Club, Washington, D. C., June 3 and 4. Thus is brought into being the greatest national engineering society in the world.—*Mining and Metallurgy*, July, 1920.

In laying the foundation last week for a national federation of engineering societies, the Organizing Conference at Washington, D. C., took action which will add a new chapter to American engineering history. The two-day meeting of delegates representing more than sixty national, state and local societies ..... was unique in its purpose in the widely representative character of its participants and in the spirit of coöperation and service which animated every session and which, at times, seemed to transform the delegates from mere technical men concerned chiefly with the details of engineering construction and design into apostles of a new order of professional solidarity.

Never before have engineering organizations throughout the country enjoyed the opportunity that is now presented to them of affiliating to secure united action.

The conference was truly remarkable in its representative character, as indicated by the list of societies and delegates. ..... Engineers have been criticised, and just so, for their professional aloofness. During the past decade or so the profession has become highly specialized and where, in former times, we had only "engineers" we now have civil, mechanical, electrical, mining, industrial, automotive, and scores of other classifications. This specialization has tended to segregate engineering into groups working more or less independently. At the conference, however, engineers of all kinds met and worked together.

The federation of engineering societies, as did the conference which created it, offers to technical men, for the first time in their history, an opportunity of presenting a *united* front on matters of civic and economic import.—*Engineering News-Record*, June 10, 1920.

June third and fourth were epoch-making days in the history of American Engineering. On those dates one hundred and twenty-three representatives of sixty-one engineering societies met at Washington and instituted an organization through which the united engineering talent of the country can function for the service of the public and the progress of the profession. The stage is now set, the program prepared in which the engineer is to take a larger part. Not a more active part, for his has always been the working role, but more prominence given to his part. Less work behind the scenes and in the supporting cast and more of the headlines. The engineer has been trained and used to think and do rather than talk. He has been content to be the servant of the administrator at a price—*Power*, June 15, 1920.

An epoch-making step in engineering organization was taken in the Washington conference of technical society representatives which decided upon the formation of a federation of these technical associations. This is the first all-embracing movement of the engineers to place their activities upon a full professional basis comparable with that of the other learned professions of law, medicine and the clergy; and as such is of the greatest importance. For a number of years the several larger national engineering societies have been affiliated through the Engineering Council and other channels, but the work thus done is limited in many ways. It is a happy development, therefore, that gives us the larger agency which is now assured.—*Coal Age*, June 10, 1920.

Increased prestige and opportunity for service came to A.A.E. out of the conference in Washington June 3 and 4 called by the Joint Conference Committee of the national technical societies. Little if any occupation of the field occupied by A.A.E. is contemplated by the Federation. On the one hand is the Federation composed of societies and created for the public good; on the other hand is the democratic organization of engineers devoted primarily to helping the individual engineer to get on in life. A.A.E. was apparently recognized as the servant of the profession in the welfare field. There can therefore be nothing on the part of A.A.E. but cordial good wishes to the Federation.—*Professional Engineer*, July, 1920.

An event of immense importance to the engineering world took place in Washington, June 3 and 4. The large number of great engineering organizations represented would alone stamp this meeting as of tremendous import, but the object sought places it above that of any engineering gathering ever held. If the plan projected becomes workable, the engineer will at last be given the recognition due him for his public-spirited, though hitherto too modest, service. The American people *need* successful engineers in public office, along with successful business men and manufacturers, as we called to your attention in our recent editorial: "Not Politics—But Common Sense." The American people need engineers to take active interest in the great national problems. The Engineers need the American people to take an interest in THEM—a human, urging interest. It was to bring about the satisfying of this mutual need that the Federation was first proposed.—*American Machinist*, June 17, 1920.

The Organizing Conference has met and fulfilled its mission.—But if the new organization undertakes to trespass on the jurisdiction of A. A. E., in a spirit of competition rather than coöperation, by duplicating the work that A. A. E. began and has continued with such marvelous success, then justification for the confederation is difficult to find. There is abundant room for two comprehensive organizations of engineers, provided that one busies itself with joint technical matters and the other with social. A. A. E. has avowed its purpose to adhere to the latter. For any other organization to become a competitor in this work would be an act to invite dissolution rather than consolidation, an act to inspire the belief that after all engineers learned nothing from their war experience.—*Engineering World*, July, 1920.

French Society Presents A.S.M.E. Honorary Membership to M. Rateau

THE Société d'Encouragement pour l'Industrie Nationale conferred Honorary Membership on M. Auguste C. E. Rateau at its meeting on May 8. In a letter of greeting to the Société, Past-President M. E. Cooley, who was in office at the time the Society conferred this award both on M. Rateau and on M. de Freminville, another of his countrymen, thanked the French organization for extending this courtesy to our Society. Dean Cooley wrote:

GENTLEMEN:

I have the honor to convey to the Société d'Encouragement pour l'Industrie Nationale the greetings of The American Society of Mechanical Engineers, and to express the great pleasure that our President and Council feel in the gracious coöperation of the Société d'Encouragement pour l'Industrie Nationale in conferring honorary membership in The American Society of Mechanical Engineers on M. Rateau, who, much to their regret, was unable to be present at our annual meeting in December, 1919, to receive the certificate of membership in person.

Permit me also to say that this willingness of our confrères in France to assume the responsibilities and perform the functions of a sister society in America roused in us anew the spirit of friendship which had its birth in the splendid service rendered America by your gallant and intrepid Lafayette.

It was our desire in conferring honorary membership on MM. Freminville and Rateau, in addition to recognizing men of great distinction in the profession of engineering to give France additional evidence of America's appreciation of your country and your countrymen in stemming the recent tide which so nearly overwhelmed civilization and which unchecked might have precipitated the world into another dark-age period.

In the belief that France and America will always be found standing together in the cause of right against wrong, in peace as well as in war, I have the honor to remain,

Most respectfully
(*Signed*) MORTIMER E. COOLEY.

PRESENTATION ADDRESS OF M. DE FREMINVILLE

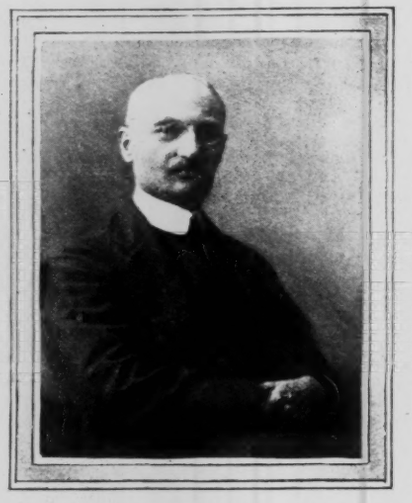
M. de Freminville, member of the Council of the Société d'Encouragement, and honorary member of The American Society of Mechanical Engineers, had been authorized by the Society to present at a public meeting of a great French technical association, the certificate of honorary membership which The American Society had conferred upon M. Auguste Rateau. In presenting

the certificate to M. Rateau, and thereby conferring upon him Honorary Membership in the Society. M. de Freminville expressed the sentiments of American engineers in desiring to bestow this honor and reviewed the features of M. Rateau's professional accomplishments which led to his selection for honorary membership. He said in part:

MY DEAR M. RATEAU:

At this time when economic relations are so difficult to regulate among the countries of the world, and when there is so much clashing of individual interests, it is most pleasing to meet with men who desire above all to show their sincere attachment to France and their desire to collaborate with her. This is what the members of the Council of The American Society of Mechanical Engineers have desired to emphasize in conferring upon you honorary membership in their Society, a distinction extremely rare, and appreciated in America as the greatest that can be conferred upon an engineer at home or abroad.

This honor was bestowed upon you at the Annual Meeting of the Society, held on December 2 last in New York. During my recent



M. AUGUSTE C. E. RATEAU

visit to the United States I had the great pleasure of attending that meeting, and I remember well the reception which was accorded me, in the course of which I was requested to present this certificate to you.

It was very natural that the choice of the Mechanical Engineers should fall on a man whose scientific accomplishments, as well as his record of practical achievements, are universally recognized. But permit me to assure you that our friends in America had the intention of honoring in you the singular genius of France for which they have the greatest admiration and the greatest respect.

The Americans, emboldened by the immense resources of their country, are remarkable for their great conceptions. Not being influenced by customary traditions, they have realized that the surest means of enhancing the value of their possessions is to appeal to the teachings of science. However, in spite of their love of doing things in a rush, they have not accepted conclusions without going back to their sources and without studying the works of the pioneers who have opened new fields of endeavor, and it is this policy which has made known to them the French men of science whose names are written on the walls of this society which so many of them have visited. Whatever the originality of their works, the Americans like to connect them with those of French scientists. They have never ceased to follow the development of science in our country and know that you have taken a great part in its development: that you are one of the pioneers in the manufacture of steam turbines and turbo-compressors and high-pressure centrifugal pumps; that you are the author of rules and formulæ for the steam flow through orifices of various forms and the originator of methods for the calculation and design of steam turbines, now in common use; that you have made important contributions to the theory of the hydraulic turbine and of water hammer in conduits under pressure and have studied numerous types of centrifugal and helicoidal ventilators; that you are the inventor of the steam turbine operating under mixed pressure and of the rational utilization of exhaust steam, and that you manage with genius the works in which your turbo-compressors and other high-speed turbine machinery are being built. Moreover, that you have taken an active part in the application of turbines to warships, that important researches in ballistics are due to you and that you are the inventor of the supercharger which greatly increases the efficiency of aeroplanes.

Although the Americans admire scientific attainment, they are first of all a people who attain results, and the enumeration of your accomplishments shows that under this head you are also entitled to their admiration.

RESPONSE BY M. RATEAU

M. Rateau, in accepting the certificate of honorary membership, responded to M. de Freminville's speech of presentation, saying in part:

It is a source of great satisfaction to me to be so highly honored by The American Society of Mechanical Engineers, but in a great measure it is also a source of pride to all the engineers in France who are being honored in my person by the American society.

At this hour when we are confronted with the tremendous work of reconstruction of the devastated regions, it is certainly a great consolation to know that our friends across the Atlantic think of us, and are to be associated with us in that task. And not alone in the work of reconstruction can we work together, but there are very many questions, the solution of which it would be highly desirable to discuss in common, such as for example, as patents, industrial research, bibliographic reports, standardization of mechanical quantities, technical education, etc., etc.

The scientific organizations of the Allied countries and of the United States have recently formed an international council of scientific research, the principal object of which is the coördination of the activities in the different branches of science and its applications. Now, applied science needs as much collective effort and organization as pure science, for there is in this field great need of coördinating the work that is now being done by the various laboratories without any joint purpose, and I take this occasion to point out that a central organization instituted by the principal societies of engineers in America and in the Allied countries, would be well qualified to occupy itself with this important matter.

In the matter of education we Frenchmen could profit much by visiting the United States and learning what is being done there in this regard. Indeed, we have had accounts of recent developments in America, such as that which M. de Freminville has given us on the progress of the Taylor System, and the work of Omer Buyse, which contains an extensive exposition of the methods of teaching in the schools of the United States. But, in spite of these efforts, the American methods remain as yet unknown by the greater part of our educators and people.

There is in France now a well-directed endeavor to reform our methods of teaching, but nothing much has yet been accomplished. Our ideas, our methods, except in special cases, are the same as they were fifty years ago. However, the time of pure speculative learning is past, and in order that we may not be overcome and ruined by our rivals in industry, in commerce, and in agriculture, it is necessary for us to have energetic men of action, and not dilettantes.

All our teaching, remarkable as it is from many points of view, seems to result in destroying initiative and energy. It cultivates, it is true, the various essential faculties of man: memory, intelligence, rectitude, logic, exact reasoning, elegance of thought and expression, etc.; but are there no abuses? Is the memory not overcharged with a number of useless details which dim the fundamental truths; and then is our teaching sufficiently comprehensive? Is an attempt made to develop also, general ideas, spirit of observation, independence of spirit, intuition, and above all courage for responsibilities, and a number of other qualities useful to the men of action? Very little, indeed.

Forgive me for making a personal reference. I have been a professor of pure and applied science and, having started young in the profession, I have followed the usual errors. Now that I have seen and studied teaching methods in other countries, have visited many technical schools and other laboratories in America, England and Germany, and have given considerable thought to their methods, I can truly say that if I were to undertake teaching again, I would adopt radically different methods with the conviction that my students would derive a much greater benefit.

Why should we not send our best men, those capable of becoming professors, to foreign countries, particularly America, where they can see for themselves the results obtained by foreign methods of teaching? A few months would be sufficient and they would be admirably received there.

Instruction trips have been organized for young engineers, but it would be more profitable still to organize trips for men capable of comparing our methods with those of other peoples, and of deriving a great profit from their study. I for one am sure that it would be time and money well spent.

Reciprocally, others can learn from us what is best in our methods. These, however, are fairly well known. Our schools of the last century, particularly l'Ecole Polytechnique, that admirable creation of the great men of the Convention, have served as models to numerous institutions outside of the boundaries of France, with such modifications as have been necessitated by special local conditions, and the progress of technical science. It is now our turn to look about. To examine and to study the achievements of our contemporaries with a view to benefiting by them, can never be a sign of inferiority, but exactly the reverse.

M. Baclé, vice-president of the Société d'Encouragement, in the name of that society presented his compliments to M. Rateau as well as to M. de Freminville for their election to honorary membership in The American Society of Mechanical Engineers, a distinction as rarely accorded to strangers as that of honorary membership in the Institution of Naval Architects of England.

M. Baclé read the letter sent to the Société d'Encouragement by President Cooley and the Council of the Society. He said that the members of the former body were very much impressed with the marks of sympathy and friendship of their American confrères, to whom he presented the thanks of the Société and his hope that their bonds of friendship might be still further strengthened.

BIOGRAPHY OF AUGUSTE RATEAU

M. Auguste Rateau was born on October 13, 1863, at Royan (Charente-Inférieure), France. His successful career in college at L'Ecole Polytechnique—where he graduated as honor man—and later at the Technical School of Mines, completed in 1888, presaged the distinguished life of service he has lived as an engineer.

M. Rateau typifies the eminently practical technician. He has excelled as much in the application of theoretical mechanics to the study of engineering phenomena as in the practical utilization of the machines he has perfected theoretically. For twenty years professor of engineering, he became celebrated by his numerous theoretical and experimental researches, particularly concerning the mechanics of fluids. It was during this time, in 1899, that he won the Fourneyron Prize, which had been offered by the French Academy of Sciences to any one suggesting any improvement in the theory of nozzles and confirming his results by experiments.

Some time later M. Rateau's renown had reached America. In 1904 the University of Wisconsin conferred upon him the degree of Doctor of Laws, "in recognition of his achievements as a mechanical engineer, as a contributor to the science of the flow of fluids, as a distinguished inventor of steam-turbine engines, and as an author of standard books in engineering."

In 1906, on the occasion of the celebration of the fiftieth anniversary of the Society of German Engineers, the Technical University of Higher Studies at Charlottenburg conferred upon M. Rateau the degree of Doctor of Engineering. A similar tribute was paid him by the Société de l'Industrie Minérale in 1908, and also recently by the University of Birmingham, England, and by the Institution of Mining Engineers of England.

M. Rateau's technical works comprise: Theoretical and experimental studies of the mechanics of fluids—air, steam, water—and of the machines operated by these fluids—fans and centrifugal pumps, hydraulic and steam turbines, nozzles, air propellers, etc.; aerodynamic studies (1909); turbo-compressors for aeroplane engines (1910); and the theory of aeroplanes (1919).

M. Rateau's practical contributions to industry are attested by the numerous patents bearing his name, which have been used to great advantage in industrial countries. These are spoken of in detail in M. de Freminville's address, which appears above.

NEWS OF THE ENGINEERING SOCIETIES

Conference on Human Relations in Industry, Annual Convention of National Electric Light Association, General Meeting of the American Iron and Steel Institute

Conference on Human Relations in Industry

There will be held this year at Silver Bay, Lake George, New York, August 27 to 29, a conference on Human Relations in Industry. Over six hundred representatives of industry are expected to attend, including some of the most prominent industrial leaders. Among the speakers who have already accepted are Allen T. Burns, Americanization Study of the Carnegie Foundation for the Advancement of Teaching; F. J. Kingsbury, president, Bridgeport Brass Company; Clarence H. Howard, President, Commonwealth Steel Company; C. J. Hicks, Assistant to the President, Standard Oil Company; R. B. Wolf, Consulting Engineer; S. J. Carpenter, Lumber Manufacturer; L. P. Alford, Editor, *Industrial Management;* and Timothy Healy, International Brotherhood of Stationary Firemen.

A similar conference held at Silver Bay last year, attended by five hundred prominent industrial leaders and others, created a demand for a larger conference this year. The greatest problems of the day are industrial. The most important factor in industry is the human factor. Men dealing with the human factor want to get together, exchange experiences, and discuss these matters with experts in the field; a conference at Silver Bay affords the ideal opportunity. Members of the Society who would like to attend should reserve accommodations through Mr. Fred H. Rindge, Jr., 347 Madison Ave., New York City.

National Electric Light Association

THE forty-third annual convention of the National Electric Light Association was held at Pasadena, Cal., on May 18-22. The deliberations forcefully indicated that the public utilities of the country are no longer facing the question of obtaining business, but rather that of obtaining funds with which to finance the extensions necessary to meet the rapidly increasing demands for electric service. Coupled with the appreciation of the seriousness of the financial situation was the realization that utilities are essential public servants and that their salvation lies in close relationship with public sentiment.

Numerous committee reports and technical papers were presented. One of the most important, complete and comprehensive reports was that of the committee on water-power development. It contained statistics of present and potential water power in the United States. The latest authentic estimate shows there is approximately 50,360,000 hp. of potential undeveloped water power in the United States, and only 9,823,540 hp. of developed water power. Of the potential maximum power, 68.6 per cent lies in California, Oregon, Washington, Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Wyoming. Of the total maximum potential water power of the United States, 74.3 per cent represents undeveloped power coming under federal jurisdiction. In the western states 94 per cent of the maximum potential water power is in this class. In other words, practically all of the future development of water power in the western states, covering approximately 70 per cent of the total potential water power of the country, will be dependent upon federal action in the matter of issuance of workable permits for the development of these projects. Only 16.6 per cent of the maximum potential water power has been developed up to the present time. For the western states this proportion is only 6.5 per cent. In the case of central and eastern states, particularly the New England states, a comparatively large portion of the potential water power has been already developed.

Figures tabulated by districts showed that the per capita use of electricity in the far-western states is 2.21 times that of the remainder of the nation. Electric power rates average 1.65 cents per kw-hr. in the western section, as compared with 2.19 cents per kw-hr. elsewhere in the country.

Reference was made to projected developments in eastern states. More than 1,000,000 hp. is contemplated in Alabama, North Carolina, Georgia and Maryland. Electrification of

the western trunk-line railroads will require development of a portion of the water power in that territory. Data obtained from 52 power companies of the far-western states, showing their loads during the past ten years, and also their estimated loads up to and including 1928, were obtained and compiled for presentation in the report in connection with graphic charts. They show that during the next ten years the expected development of power in the West will rise to the vast total of 1,776,260 kw. At the present prices for material and labor this improvement will involve an investment of over $700,000,000.

That increasing costs and the scarcity of labor are resulting in the more general and more rapid commercialization of electricity and electrical appliances, was stated by John G. Learned, chairman of the commercial section. Electric furnaces for steel making, he said, are now almost a necessity and many have been installed this year for melting brass. Further advances have been made in the application of electrical energy in the reduction of copper, zinc, and aluminum, and in the manufacture of nitrates and chlorine compounds. Electricity for ice making has been developed to such a degree in some places that entire communities are dependent upon central-station service for ice. Industries are employing small electrical appliances to facilitate production.

An address on The Use of Central-Station Power in Electric Furnaces was delivered by Robert M. Keeney, director of the department of metallurgical research, Colorado School of Mines. He pointed out the great possibilities for central-station service in the electric-furnace field, stating that over 200 companies in this country have furnace loads that are considered very desirable. Electric melting of steel and scrap to produce low-grade pig iron has a big future in the western states. There are 875 electric furnaces in the world, of which 363 are in service in the United States, of a total capacity of 1600 tons, with an input of 600,000 kva. The production of electric steel in this country totaled 500,000 tons last year. Electric furnaces have a poor load factor, but this is due mainly to poor operation, the tendency in design being to increase the demand input per ton. Heavy reactances are being eliminated. Speaking further of the relation of the electric furnace to central stations, Mr. Keeney said that small furnaces operating 24 hours per day should be encouraged. He also referred to the development of brass melting by electricity.

American Iron and Steel Institute

THE seventeenth general meeting of the American Iron and Steel Institute was held in New York on May 28. The opening address by Judge Gary dealt with business conditions in the industry. He referred to the panic of 1907 when the industry had successfully confronted the difficulties which arose in that critical period, and expressed his confidence that now in another period of stress the iron and steel men were ready to do their full duty again.

Joseph G. Butler, Jr., Youngstown, Ohio, spoke on the contribution of the iron and steel industries to the war, stating that a conservative estimate made from the latest information at hand placed the amount of steel contributed to the combined armies and navies of the Allied countries at not less than 100,000,000 tons.

The technical papers were of the customary high order. George Otis Smith, director, United States Geological Survey, spoke on the rapidly diminishing oil resources of the United States and on the relation between the steel and oil industries. It appears that in terms of oil the decade 1910-1920 has witnessed a transition from over-supply to over-demand. Ten years ago the wells of the United States were adding to our reserve stocks 15,000,000 bbl. in a year; in the last nine months our stored petroleum has been drawn upon to the extent of 15,000,000 bbl. The first three months of 1920 have established a rate of domestic production that if unchecked will mean a total for the year of 415,000,000 bbl., or nearly twice the output of 1910, and a rate of consumption that would make the year's requirements more than 490,000,000 bbl., or one-seventh more than last year's consumption. An estimate of the petroleum resources of the world, to which Mr. Smith referred, gives 60,000,000,000 bbl. as the total figure, with 7,000,000,000 bbl. as the quantity remaining available in the ground in the United States. Thus, if our present rate of consumption of nearly half a billion barrels per year continues unchecked, our estimated supply cannot last fifteen years longer.

Mr. Smith also discussed the possible remedies. The conversion into motor benzol of the light oils obtained as coke by-products in steel manufacture cannot be regarded as promising enough motor fuel even to meet the present increase in demand. Steel plants now in operation and under construction have a capacity of less than 2,000,000 bbl. a year. A better hope lies in exploiting the oil-shale resources of the United States, as their oil content is fairly comparable with the petroleum reserves of the world. But as the oil thus obtained could not be as cheap that that flowing from the wells, it is not at all unlikely that the next generation of American business men will see their trade rivals across the Atlantic turning the wheels of industry and commerce with cheaper oil than will be available in the American markets. Concluding his paper, Mr. Smith urged discouragement of the use of fuel oil as a substitute for coal in stationary power plants, and pioneering by American oil companies in other countries, particularly in South America, which continent is credited with a third more oil reserves than the United States.

The report of progress in an investigation on the fatigue of metals under repeated stress, being conducted under the auspices of the National Research Council, Engineering Foundation and the Illinois Engineering Experiment Station, was presented by H. F. Moore, research professor, and J. B. Kommers, associate professor of engineering materials, University of Illinois, Urbana, Ill. It has been ascertained that the cause of failure under repeated stress is not due to crystallization of metal, as it has been thought, but to the breaking up of crystals within the metal. Metals while being subjected to fatigue were observed under the microscope, and it was found that the crystals of which the metal was composed would allow deformation to occur by movement along certain gliding planes within them. Fatigue failure would follow a path through the crystal grains themselves rather than along their boundaries, and this was true even though in going from one crystal to another the plane of failure would change its direction, because of the different orientation of the crystals. The primary cause, therefore, of fatigue failure is localized deformation. This deformation in any particular crystal is very small in amount, and apparently even very accurate and sensitive extensometers cannot detect the deterioration which is going on.

Tests conducted with apparatus of extreme sensitiveness showed that the action of materials within the ordinary elastic limit is not perfectly elastic. For instance, when a specimen is first loaded in tension, and then the load is reduced to zero, the return path of the stress-deformation curve does not coincide with the original path, but lies slightly lower, the deformation seeming to lag behind the stress, so that when the stress is zero the deformation of the specimen is not yet back to zero. If now the specimen is loaded in compression, and the load reduced to zero, it is found that a loop has been formed by the stress-deformation curve. This loop is called a mechanical hysteresis loop, from analogy with magnetic hysteresis. The area of this loop represents energy which has been absorbed by the specimen, but which has not been given back again. In each cycle of stress, therefore, there is a small amount of work done because of the inelastic action of the material. It is planned to complete a series of fatigue tests of several typical steels accompanied by very careful static tests, in order to secure data as to the relation of fatigue-resisting power to the ordinary static elastic properties.

Other technical papers were: The Microscope and the Heat Treatment of Steel, by Albert Sauveur; The Acid Open-Hearth Process, by B. E. L. De Maré; Pipeless Rolled Products from Annular Blooms, by C. A. Witter; and Welfare Work in the Steel Industry, by C. L. Close.

LIBRARY NOTES AND BOOK REVIEWS

AIRMAN'S INTERNATIONAL DICTIONARY. Including the most important technical terms of aircraft construction; English, French, Italian and German. Edited by Mario Mele Dander. Charles Griffin & Co., Ltd., London, 1919 (J. B. Lippincott Co., Philadelphia). Cloth, 4 x 6 in., 227 pp., 6s.

The terms in this dictionary are classified under systematic headings, so that those relating to a particular part of the airplane are brought together and an alphabetical index is provided.

ASBESTOS AND THE ASBESTOS INDUSTRY AND OTHER FIREPROOF MATERIALS. By A. Leonard Summers. Sir Isaac Pitman & Sons, Ltd., London, New York, n. d. Cloth, 5 x 7 in., 107 pp., illus., plates, 2s. 6d.

This little book gives a non-technical account of asbestos, its sources, varieties and uses, that is intended for users of this material and for general readers, rather than for those in search of detailed information.

AUTOMOBILE CONSTRUCTION AND REPAIR. With Questions and Answers. By Morris A. Hall. American Technical Society, Chicago, 1920. Flexible cloth, 6 x 8 in., 711 pp., illus., $3.50.

In this book the various parts of the automobile are described in detail, and explicit instructions for their adjustment and repair are given. The volume is intended for owners, chauffeurs and repairmen.

CEMENT. By Bertram Blount, assisted by William H. Woodcock and Henry J. Gillett. Longmans, Green & Co., New York, 1920. Cloth, 6 x 9 in., 284 pp., illus., plates, tables, $6.

This monograph, like its companion volumes, is intended to give a connected, balanced account of the cement industry in the light of our scientific knowledge of the principles underlying it. Processes are explained so far as they are necessary to elucidate principles, but no attempt is made to present minute technical details.

DIE HELMOLTZSHE WIRBELTHEORIE FÜR INGENIEURE. By G. Bauer. R. Oldenbourg, München & Berlin, 1920. Paper, 7 x 10 in., 146 pp., illus., diagrams, 14 marks.

The hydrodynamic problems met in such fields as airplane and ship building call for an acquaintance with the theory of vortex motion, but this theory, although it has for some time taken a considerable and useful place in electrical theory, is less well known by those engaged in other fields, it is the author's opinion that the chief cause of this ignorance is the lack of any work from which the engineer can obtain an understanding of the theory of vortices with a minimum of effort, a lack that the present monograph is intended to supply. The method adopted is that of a commentary on Helmholtz's famous paper of 1858 on vortex motion. The paper is presented in full, with extensive illustrations and explanations. Helmholtz's two answers to Bertrand's papers on the motion of fluids are also included.

DYKE'S AUTOMOBILE AND GASOLINE ENGINE ENCYCLOPEDIA. Treating on the Construction, Operation and Repairing of Automobiles and Gasoline Engines; also Trucks, Tractors, Airplanes and Motorcycles. By A. L. Dyke. Twelfth edition. A. L. Dyke, St. Louis, 1920. Cloth, 7 x 10 in., 940 pp., illus., charts, $6.

This well-known book has undergone its annual revision, and has also been enlarged by the addition of material on motor trucks, tractors, motorcycles and airplanes. With its wealth of illustrations and its clear practical information on all subjects connected with automobile operation and repair, it is well named an encyclopedia of the subject.

FORGE PRACTICE AND HEAT TREATMENT OF STEEL. By John Lord Bacon. Third edition, revised and enlarged by Edward R. Markham. John Wiley & Sons, Inc., New York, 1919. Cloth, 5 x 8 in., 418 pp., illus., tables, $1.75.

This is a textbook to accompany a course in forge practice, which explains the principles and provides a suitable set of exercises, but does not attempt to give minute instructions for making tools. The present edition has been enlarged by the inclusion of instruction in the heat treatment of steel.

GRAPHIC PRODUCTION CONTROL. By C. E. Knoeppel, assisted by various members of the author's firm and staff. The Engineering Magazine Co., New York, 1920. Cloth, 6 x 9 in., 477 pp., illus., diagrams, charts, $6.

An inaccurate review of this book was published in the May issue of MECHANICAL ENGINEERING. The book is not intended, as was stated, "to provide a complete description of the proper methods of making graphic charts and of applying them to industrial problems." It reveals a system for the control of production using graphics, charts, diagrams, dispatch boards, control boards and other forms of mechanism to visualize the facts by which control is secured.

HANDBOOK OF NATURAL GAS. By Henry P. Westcott. Third edition. The Metric Metal Works, Erie, Pa., 1920. Cloth, 5 x 8 in., 725 pp., illus., plates, charts, tables, $3.75.

The intention of this work is to supply a one-volume manual covering the entire industry in a practical way. It begins with a brief statement of the geology of the gas fields, followed by a history of the industry, and then proceeds successively to the properties of gases, field work, measurement of gas wells, pipeline construction and capacity-gas compression, measurement, regulation, distribution and consumption. Casinghead gasoline, the carbon black industry, helium and acetylene welding are also discussed. The present edition has been revised and enlarged.

HARDENING, TEMPERING, ANNEALING AND FORGING OF STEEL, including Heat Treatment of Modern Alloy Steels. A Complete Treatise on the Practical Treatment and Working of High and Low-Grade Steel, Comprising the Selection and Identification of High and Low-Carbon Steel, and Modern Chrome-Nickel and Chrome-Vanadium Alloys; the most Modern Hardening, Tempering, Annealing and Forging Processes, the Use of Gas Blast and Electric Furnaces, and Heating Machines. By Joseph V. Woodworth. Fifth edition. The Norman W. Henley Publishing Co., New York, 1919. Cloth, 6 x 9 in., 321 pp., illus., tables, $3.

The author has prepared a compendium of practical information on the subjects mentioned, based on trade literature and personal experience, for the use of mechanics and other users of steel. The present edition has been revised and enlarged, and a section treating of the newer alloy steels has been added.

INTERNAL-COMBUSTION ENGINES. Their Principles and Application to Automobile, Aircraft and Marine Purposes. By Wallace L. Lind. Ginn & Co., Boston, (Copyright 1920). Cloth, 6 x 8 in., 225 pp., illus., chart, $2.20.

This is a brief, practical, up-to-date text for students, covering the theory and operation of these engines, but omitting the question of design.

INTERNATIONAL COMMERCE AND RECONSTRUCTION. By Elisha M. Friedman. With a foreword by Joseph French Johnson. E. P. Dutton & Co., New York, copyright, 1920. 432 pp., 5 x 8 in., tables, $5.

Beneath the military campaigns of the war, a silent economic process has been changing the character of the commerce of the world. Profound changes have taken place, which this book attempts to trace in detail, and the principles of which it aims to discuss. It recites some of the facts essential to the formation of a new commercial and financial view and advocates a definite trade policy for the retention of our commercial gains from the war years.

INVENTIONS, Their Development, Purchase and Sale. By William E. Baff. D. Van Nostrand Co., New York, 1920. Cloth, 8 x 5 in., 230 pp., $2.00.

The author of this work discusses the marketing of inventions. The subject is considered from the various points of view of the inventor, the capitalist or investor, and the manufacturer, and advice given to each as to the methods for making a correct judgment of the value of any invention.

A KINETIC THEORY OF GASES AND LIQUIDS. By Richard D. Kleeman. First edition. John Wiley & Sons, Inc., New York, 1920. Cloth, 5 x 8 in., 272 pp., tables, $3.

The object of this book is to formulate a kinetic theory of certain properties of matter, which shall apply equally well to mat-